REPORT RESUMES

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HANDBOOK, TEACHING SCIENCE TO EDUCATIONALLY DISADVANTAGED YOUTH.

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DESCRIBED ARE PROCEDURES AND LABORATORY MATERIALS WHICH ARE OUTGROWTHS OF A RESEARCH PROJECT OF THE SOUTHEASTERN EDUCATION LABORATORY FOR THE TEACHING OF SCIENCE TO DISADVANTAGED STUDENTS IN GRADES 7, 8, AND 9. PART 1 DEALS WITH THE CRITERIA USED IN DEVELOPING PROCEDURES AND MATERIALS FOR USE WITH EDUCATIONALLY DISADVANTAGED. INCLUDED ARE (1) THE RATIONALE FOR AN IMPROVED SCIENCE PROGRAM FOR THE EDUCATIONALLY DISADVANTAGED, (2) WORKING ASSUMPTIONS MADE REGARDING EDUCATIONALLY DISADVANTAGED YOUTH, (3) THE GUIDELINES FOR DETERMINING SCIENCE EXPERIENCES FOR THE EDUCATIONALLY DISADVANTAGED, AND (4) THE GUIDELINES FOR DETERMINING HOW TO TEACH SCIENCE TO THE EDUCATIONALLY DISADVANTAGED. PART 2 ILLUSTRATES PROCEDURES AND ACTIVITIES FOUND EFFECTIVE IN WORKING WITH EDUCATIONALLY DISADVANTAGED STUDENTS IN GRADES 7, 8, AND 9 AT RIBAULT JUNIOR AND SENIOR HIGH SCHOOL, JACKSONVILLE, FLORIDA. EMPHASIS IS PLACED ON CONCRETE EXPERIENCES AND THE QUALITY OF THE EXPERIENCES. THE FORMAL TEXTBOOK HAS BEEN ELIMINATED AND THE NEW MATERIAL HAS BEEN WRITTEN WITH THE ASSUMPTION THAT THE STUDENTS HAVE A LIMITED READING ABILITY AND A POOR COMMAND OF THE ENGLISH LANGUAGE. A SUGGESTED FORMAT FOR THE TEACHER TO FOLLOW IN DIRECTING THE CLASS IS PRESENTED FOR EACH LESSON ALONG WITH STUDENT PRINTED MATERIALS. EXTENSIVE USE IS MADE OF AUDIOVISUAL MATERIALS, PARTICULARLY OVERHEAD TRANSPARENCIES. TEACHER AND STUDENT MATERIALS ARE DESCRIBED FOR SUCH UNITS AS (1) FIRST CLASS LEVERS, (2) THE INCLINED PLANE, (3) THE PULLEY, (4) FRICTION, (5) HEAT, AND (6) HEAT, CHEMICAL REACTIONS, AND BIOLOGICAL SYSTEMS. APPENDED ARE (1) A SUGGESTED CALENDAR FOR THE STUDY OF THE CHICK EMBRYO DEVELOPMENT, (2) MATERIALS AND EQUIPMENT LISTS, AND (3) MASTERS FOR USE IN MAKING TRANSPARENCIES. (DS)

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HANDBOOK:
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HANDBOOK:
TEACHING SCIENCE TO EDUCATIONALLY DISADVANTAGED YOUTH

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TEACHING SCIENCE TO EDUCATIONALLY DISADVANTAGED YOUTH

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PREFACE

In launching this project the authors searched the literature extensively to find what others are doing for disadvantaged youth. Basic premises for the project were established. Those premises which were supported in the pilot project are stated in Part I of this report.

The procedures, the written material for the teacher and the students, and most of the laboratory materials were developed by the authors. Some of the activities, however, which met the criteria established for the project were chosen and adapted from materials commercially available.

The testing of the procedures and activities presented in Part II of this manuscript took place in the Ribault Junior and Senior High Schools in Jacksonville, Florida. From a pool of 250 economically deprived, educationally disadvantaged youth identified in grades 7, 8, and 9 of these schools, a smaller pool of 180 students, (60 seventh, 60 eighth, and 60 ninth grade students), who also appeared to be underachievers, were selected. By random means, a class of 30 youth for experimental sections, and 30 youth for control purposes, were selected at each grade level. The procedures and materials presented in Part II were experienced by the 90 students in the experimental classes.

A detailed account of the research procedures used in this project is to be found in the report made to the Southeastern Education Laboratory, Inc., of Atlanta, Georgia, which organization made possible this Project.

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PART I

PREFERENTIAL TREATMENT ESSENTIAL FOR EDUCATIONALLY DISADVANTAGED YOUTH

NEED FOR AN IMPROVED SCIENCE PROGRAM FOR EDUCATIONALLY DISADVANTAGED YOUTH

In general, economically deprived children are also educationally deprived. They have had a narrow range of experiences in a limited environment, hence have a lack of confidence in themselves in any classroom situation. These children are limited in their ability to communicate with others orally or by means of reading and writing. They share feelings of fatalism, helplessness, dependence, and inferiority in social situations. They have, in general, experienced continued failure in school work.

It has been shown repeatedly that children who become alienated to the school remain so unless some preferential program is provided to change their attitude toward the school and toward their teachers. They have failed and will continue to fail unless a situation is arranged in which they can succeed in engaging in activities meaningful to them. So there is need to prepare appropriate curriculum materials for them and to provide a training program for their teachers. Such a program must develop in the teachers the understandings and skills and commitments essential in re-establishing a wholesome rapport with these educationally disadvantaged youth and in involving them in purposeful activities.

RATIONALE FOR THE DEVELOPMENT OF AN IMPROVED SCIENCE PROGRAM FOR EDUCATIONALLY DISADVANTAGED YOUTH

Studies of teaching strategies for the educationally deprived child have emphasized the need for learning activities which are structured, concrete, and physically oriented. In addition, studies have shown that the deprived child has respect for the sciences, particularly the physical sciences. Science is a natural subject area for experiences with concrete materials. Out of carefully chosen, interesting, and closely related activities come the beginnings of formal language-abstractions used in talking about these activities. Science offers endless possibilities to simultaneously demonstrate the need for the acquisition of these communicative skills when accounting for what one observes or in projecting what may happen in a controlled experiment.

A wide variety of new science materials have been and are being developed for use in the elementary and junior high schools. Few have been extensively evaluated, and their applicability to the educational needs of the disadvantaged is open to serious question. It seemed likely that the culture of the educationally deprived child created unique demands for special materials and approaches to science learnings, especially if these learnings are to be integrated into the other areas of the curriculum. Therefore, it was one of the purposes of this demonstration research program to develop and publish materials and approaches which are found to be especially suited to the educational needs of the disadvantaged.

BIBLIOGRAPHY USED TO DESIGN THIS PROGRAM

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2. BSCS Curriculum Study Special Publication No. 4. The Teacher and BSCS Special Materials.

3. Lewis, Oscar, "The Culture of Poverty," Scientific American, Vol. 215, No. 4, October 1966, pp. 19 - 25.

4. Mackintosh, Helen K., Lillian Gore and Gertrude M. Lewis, "Educating Disadvantaged Children in the Middle Grades," Disadvantaged Children Series, O. E. 35068, U. S. Department of Health, Education and Welfare.

5. Smilansky, Moshe, "Fighting Deprivation in the Promised Land," Saturday Review, October 15, 1966, pp. 82 - 91.

LIMITATIONS OF THE PROGRAM DEVELOPED AND TESTED IN THIS PILOT DEMONSTRATION RESEARCH PROJECT

1. The program is not a complete program for use in grades 7 through 9. Instead, it is a program that was taught successfully during the second semester in grades 7, 8 and 9. The same program was taught in all three grades. Its merit was established in all three grades. What is needed is a six semester sequential science program for the educationally disadvantaged youth in the junior high school grades, developed along the lines and taught by the procedures found effective in this program. The materials and procedures reported herein are but representative of a complete program.

2. To establish the validity of the findings reported herein, a much larger demonstration-research study should be carried out with many more students, and many more teachers. There were but two teachers involved in this project. It can be said, however, under the conditions of this demonstration, the program was found effective. It can be predicted, that under similar conditions with other teachers a similar program will also be found effective.*

ASSUMPTIONS MADE REGARDING EDUCATIONALLY DISADVANTAGED YOUTH

1. Human ability is to a large extent a social product. It depends upon the opportunities in the environment for meaningful and varied experiences. In many areas it does not develop unless recognized and encouraged by society.

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*A complete report on the research aspects of this demonstration-research program is reported in the Report of "A Demonstration of the Role of Science in the Programs of Educationally Disadvantaged Youth, Grades 7-9." by Dr. N. E. Bingham, Director, made to the Southeastern Education Laboratory, Inc., P. O. Box 20867 Airport Branch, Atlanta, Georgia, 30320.

2. Educationally deprived children have had a narrow range of experiences in a limited environment, hence have a lack of confidence in themselves in a classroom situation.

3. The conceptual development and the cultural heritage of educationally deprived children is inferior to that of children in more favorable environments.

4. Because of limited experiences, educationally deprived children are limited in their ability to communicate with others orally or by means of reading and writing.

5. The child who grows up in a culture of poverty has a strong feeling of fatalism, helplessness, dependence, and inferiority in social situatio

6. By the time educationally deprived children enter school they have absorbed the basic attitudes and values of their subculture of poverty. As a result they are not ready to take advantage of the educational opportunities in the school or of opportunities that may come as a result of changed conditions during their lifetime.

7. Any significant change in the relative position of the educationally deprived child requires a preferential treatment that will compensate for his inadequacies. These children require modified teaching technique and a specially constructed curriculum if they are to succeed in school. They need special materials and devices to fill the gaps in their experience.

8. The time of readiness to learn can be advanced and the quality of development can be enriched by working with educationally deprived children before they show overt signs of readiness.

9. Deprivation is largely due to failure of environmental agents:
    a. failure to provide children with necessary nourishment before they are ready to exercise specific capacities.
    b. failure to use and develop these capacities once they are ready for exercise.

10. Although the preschool years are characterized by the most rapid change and growth and so are the most important years, yet the adolescent years are also a period of rapid change and growth, hence, these years are fruitful ones for the re-orientation and development of educationally deprived children.

11. Wherever poverty exists throughout the world there is a remarkable similarity in the style of life which may be called a "culture of poverty". This culture provides the human beings living in it with a design for living that permits their survival. This similarity is found in the structure of families, in interpersonal relations, in value systems, in spending habits, and in their tendency to live in the present with little thought of the future. The high incidence of common law marriages and of households headed by women are characteristic of this culture wherever it occurs.

GUIDELINES USED TO DETERMINE SCIENCE EXPERIENCES FOR EDUCATIONALLY DISADVANTAGED YOUTH

1. Classroom studies should be related to the students' contemporary experiences in their society. Certain aspects of historical development may be helpful, but a consideration of these for endorsement and clarification will come after the ideas are crystallized through concrete experiences.

2. A definite classroom situation must be provided in which new experiences with objects and events are related to past experiences in such a manner that new relationships are discovered. By associating several new experiences during a short period of time, an awareness of the basic principles that account for these experiences may be developed.

3. Science experiences must be developed from the common interests of the learners and result in an understanding of the basic principles of science that are related to these interests.

4. Initial learning of first level abstractions comes from observations of particular objects and events via all of the senses. First hand experiences should be emphasized.

5. There is a continuum in learning experiences that ranges from observation of particular objects and events, through those presented using multi-sensory aids, through the presentation of abstract concepts. Within the continuum of experiences, those located toward the concrete end are preferable.

6. Motivation for further learning will result from meaningful and enjoyable experiences with objects and events. Whenever possible "discovery" experiences should be planned for through "pre-eureka" procedures. Successful experiences in accounting for particular objects and events will provide motivation for additional experiences with other objects and events.

7. Audio-visual materials should be developed for use in initiating activities; for use in lieu of concrete experiences where these are impractical; and for use in providing additional enriching experiences.

8. The lack of communicative skills and the lack of self-confidence make it mandatory that educationally deprived children succeed in what they do. The tasks they undertake in school must be measured in difficulty and be ordered sequentially to guarantee success.

9. A wide range of materials together with opportunities to use these materials in meaningful ways must be provided if each educationally deprived child is to enhance his own self-confidence by noting his own growth in ideas and skills.

10. The major outcome of classroom experiences in science is to create in the educationally disadvantaged youth a desire to learn and a positive attitude toward school.

11. The school program should improve the basic skills of speaking and reading.

12. Culturally disadvantaged adolescents should be permitted to specialize in an area in which they are specially interested.

GUIDELINES USED TO DETERMINE HOW TO TEACH SCIENCE TO EDUCATIONALLY DISADVANTAGED YOUTH

1. The teacher must accurately assess the strengths, weaknesses, and interests of each child in order to counsel and guide each in his pursuit of knowledge.

2. Instruction will of necessity be largely with small groups rather than with the total class.

3. The teacher must know the content and the processes of science; the childrens' environment, their fears and concerns, and be skillful in guiding their learning experiences.

4. Educationally deprived adolescents will have had many frustrating experiences so special care must be taken to enable each to succeed in each task undertaken. This success should be used to reinforce and to motivate further learning.

5. The teacher must be willing for the child to deal primarily with specific objects, events, or persons as these objects, events or persons relate to himself, rather than to be concerned primarily with generalized activities.

6. The teacher as a discussion leader accepts every response as a contribution and by questions, suggestions, and vocabulary directs the development of the concept.

7. The teacher must be able to arrange a learning situation in which the youth's belief in himself, his self image, escalates. Each must operate responsibly in a self-directed way to build a confident self-image.

8. The teacher should become an active partner with the pupils while maintaining an appropriate teacher image fostering abilities before, as well as during, the expected maturation time for these abilities.

9. Even though educationally deprived, each child will have had many experiences that may be used to promote learning.

10. The same concepts should be developed in several ways from a number of different but related experiences.

11. The major purpose of laboratory experiences is to promote creative thinking, not to manipulate equipment.

12. Reading materials should be selected to supplement the classroom activities out of which basic principles have been developed. In this way the basic principles may be firmly fixed in mind and also skills and habits of reading may be taught.

13. Assignments should be short. Emphasis should be on quality of work rather than on quantity of work.

14. Vocabulary load should be kept at a minimum level. Special effort should be made to teach the required vocabulary.

15. Mathematical calculations should be kept at a minimum level so that measurements and quantitative treatment of results enhances rather than stifles learning.

16. Testing should be used primarily to promote learning. It should be situation centered and involve such skills as interpretation of data, application of principles, the formulation of appropriate hypotheses, as well as to enable the student to assess his comprehension.

GUIDELINES USED TO SELECT SCIENCE EXPERIENCES FOR EDUCATIONALLY DISADVANTAGED YOUTH

1. Selection of topics for individual, small group or class investigation must provide avenues that insure success. Therefore, the investigations must center around directed inquiry rather than unassisted discovery.

2. Each illustrative or investigative activity should:
    a. relate to the pupils' common experiences
    b. lead to a better understanding of the pupils' environment
    c. stem from and enhance the pupils' interests
    d. be specific rather than generalized, especially at the beginning
    e. furnish a basis for improving language skills, especially reading and oral expression
    f. be of measured difficulty so that each may succeed

3. Each piece of apparatus should be:
    a. simple so that attention may be focused on significant observations
    b. so designed as to clearly show - perhaps to magnify - the quality being observed
    c. safe to use
    d. easy to manipulate
    e. relatively durable
    f. relatively inexpensive
    g. easy to store

PART II

ILLUSTRATIVE ACTIVITIES AND PROCEDURES FOUND EFFECTIVE WITH EDUCATIONALLY DISADVANTAGED YOUTH

INTRODUCTORY DISCUSSION

The teaching procedures offered in this program are experimental. The teacher is offered the flexibility required to meet the needs of the different pupils while directing their learning activities in a meaningful, sequential manner. The major emphases are placed on concrete experiences and the quality of experiences rather than on the quantity of content.

The material is written with the assumption that the students have a limited reading ability and a poor command of the English language. The formal textbook has been eliminated placing the responsibility of instruction entirely in the hands of the teacher. He must direct the learning processes by means of student-teacher verbal interactions with emphases being placed on oral discussions, reinforcements, and the development of a sound scientific approach. One of the basic problems -- that of communication -- can be greatly alleviated by initially utilizing the students' colloquialisms.

The teaching will normally progress through three phases:

1. Initial discussion supported by audio-visual materials to stimulate interest.
2. Small group laboratory activities supported by discussions of particular relevant information.
3. Final discussion to establish a conceptual framework and lead into the next topic.

A suggested format for the teacher to follow in directing the class is presented in detail. Suggested comments to be made by the teacher to the class are written in CAPITAL LETTERS; suggested procedures and anticipated responses are written in small type. Printed materials to be used by the students are designated by the letter "A" followed by a sequential number (A - 2). These are to be reproduced by thermo-spirit masters and issued to the students at the teacher's discretion. Extensive use of audio-visual materials is necessary to provide meaningful concrete experiences.

The student activities are to be duplicated by using thermo-spirit masters. The acetates can be easily prepared from the drawings in the appendix using 3M-127 thermo-acetates. A thermo-duplicator and a spirit duplicator is the only equipment needed to prepare the student activities and prepered acetates.

INTRODUCTORY DISCUSSION

Introductory Topic - The initiation of the discussion pattern to establish rapport between the teacher and students.

The purpose of the introductory discussion is twofold; to establish a discussion pattern that reflects critical thinking and questioning, and to establish an initial rapport between the teacher and the students in the classroom. The topic consists of twenty-three separate optical illusions on prepared acetates to be placed on the overhead projector.* The students are to be encouraged to discuss the illusions freely and informally. It can be assumed that the students will be reluctant to participate for many reasons, some of which may be: (1) due to past experiences with failure, (2) peer group influences, (3) fear of giving wrong answers resulting in ridicule, and (4) being conditioned not to participate. The teacher must establish an atmosphere conducive to free discussion and questioning. Each statement should be accepted, modified as necessary, and reinforced as a contribution. By design, optical illusions will serve this purpose quite well for there is not one entirely correct answer that can be determined without intensive questioning. Use as many of the illusions as needed to establish the initial rapport.

TEACHER RESOURCE

The optical illusions should stimulate interest and improve communication in all three phases of teaching. This introductory activity is designed to "break the ice" and for orientation. The teacher should talk as little as possible but should not be reluctant to capitalize on points and suggestions that lead to the development of the pre-determined goals--that is to establish rapport and critical thinking. Most of what the teacher says is said in question form rather than expository form. His responses to student statements are largely questions or suggestions. An example would be if a student questions whether or not a line is straight, suggest the use of a straight-edge to determine the answer. The results of the discussion should develop the idea that only through questions and investigations can answers and solutions be determined.

TEACHER DIRECTION

Place a prepared acetate of an optical illusion on the overhead projector. WHAT DOES THAT THING LOOK LIKE? Encourage extensive discussion. Answer questions with questions such as "What do you think it is?" or solicit voluntary answers from the class. Capitalize on and encourage student's suggestions for determining answers in a scientific manner such as observing, measuring, inferring, and experimenting.

Follow the same procedure for other acetates.

In conclusion, point out that the same object may appear different to different individuals. This is a problem of science. Interject the idea that individuals are different in thought as well as appearance. Examples are how fat is "fat", how tall is "tall", where is "there".

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*These may be purchased from the 3-M Company. Approximate cost is $35.

UNIT I FIRST CLASS LEVERS

TEACHER RESOURCE

Every time a person moves he exerts a force and does work. Machines are used to make work easier. A force is a push or a pull. If the force moves something, work is done. Work may be expressed by the formula $W = F \times D$. Any unit of work must include a force unit and a distance unit. The force units used in these activities are those commonly used in measuring weight, namely, ounces, pounds, grams, kilograms, et. al. (The units of force, dynes and newtons, and of work, ergs and joules, are too abstract for use here). Distances may be measured in inches, feet, centimeters, meters, etc.

The resistances that are overcome by forces are gravity, inertia, and friction. It takes energy to lift something, to start something moving, to stop something when it is moving, and to push something over a hard surface or through any medium. Friction may be lessened by substituting hard surfaces for soft surfaces, by lubrication, and by substituting rolling friction for sliding friction.

Power is the rate of doing work. It takes twice as much power to do a given amount of work in half the time. Power may be expressed by the formulas:

$$P = \frac{W}{T} \qquad P = \frac{F \times D}{T} \qquad P = \frac{\text{foot-pounds}}{\text{seconds}}$$

Power is commonly measured in horsepower. One horsepower is 33,000 foot-pounds of work per minute, or 550 foot-pounds of work per second.

There are simple machines and compound machines. Compound machines are made up of two or more simple machines which work together as a unit. Simple machines are of two kinds: machines that turn, namely, the lever, the wheel and axle, and the pulley; and machines that slide, namely, the inclined plane, the wedge and the screw.

Levers are of three classes. In the first class lever the fulcrum is between the effort force and the resistance force; in the second class lever the resistance is between the fulcrum and effort force; in the third class lever the effort force is between the fulcrum and resistance force. The wedge is really two inclined planes placed back to back. The screw is an inclined plane wrapped around an axle.

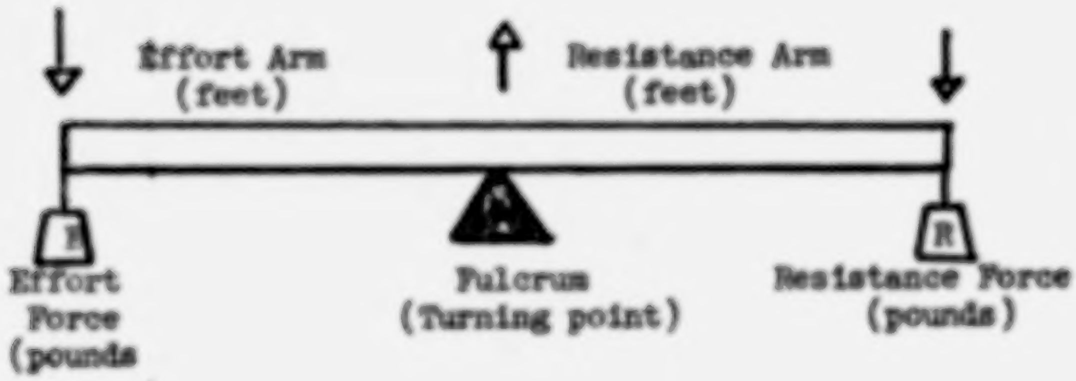
When working with machines that turn, one makes calculations of moments. A moment, or torque, is the product of a force times its distance from the fulcrum. The principle of moments is that the sum of the moments which tends to turn the machine in a clockwise direction is equal to the sum of the moments that tend to turn the machine in a counterclockwise direction. The machine is balanced when these moments are equal.

When working with machines that slide, one makes calculations of work. Input work is the product of the force times the distance the force moves. Output work is the product of the resistance force times the distance that it moves. The principle of work is that, disregarding friction input work equals output work.

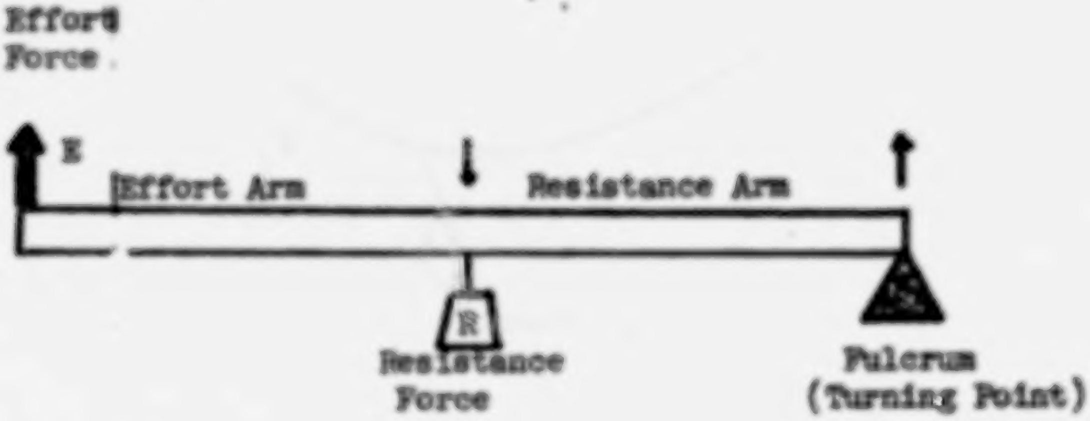
IDENTIFICATION AND CLASSIFICATION OF SEVERAL MACHINES

A. Lever

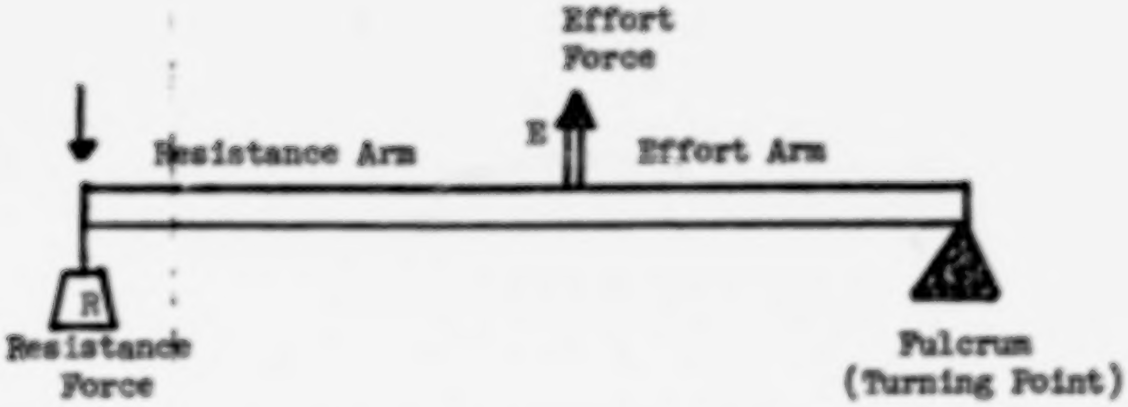
1. First class


Effort Arm
(feet)
Resistance Arm
(feet)
E
R
Effort
Force
(pounds
Fulcrum
(Turning point)
Resistance Force
(pounds)

2. Second class

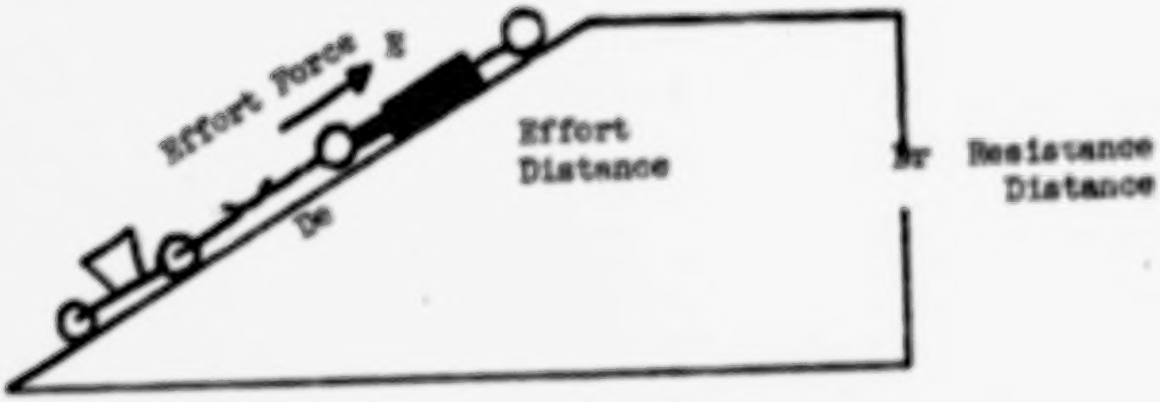

Effort
Force
E
Effort Arm
Resistance Arm
R
Resistance
Force
Fulcrum
(Turning Point)

3. Third class


Effort
Force
E
Resistance Arm
Effort Arm
R
Resistance
Force
Fulcrum
(Turning Point)

Principle of levers is that clockwise moments = counter-clockwise moments

B. Inclined Plane

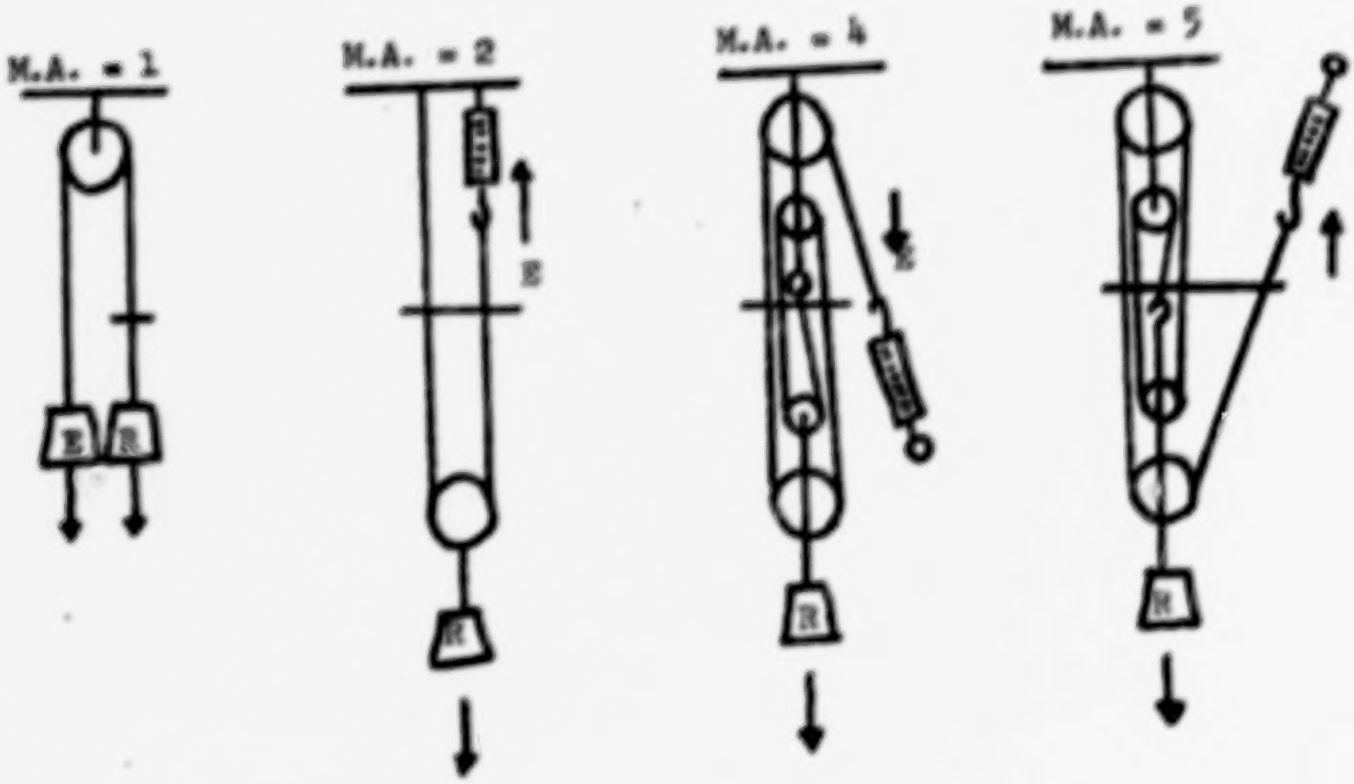

Effort Force E
Effort Distance
De
Dr
Resistance Distance

Input work = Effort force x Length of Plane

Output work = Weight of object x Height of Plane

Principle of the Inclined Plane is that, disregarding friction,
Input work = Output work.

C. Pulleys


M.A. = 1
E
R
M.A. = 2
E
R
M.A. = 4
E
R
M.A. = 5
R

E = Effort Force
R = Resistance Force
M.A. = Mechanical Advantage (number of supporting ropes)
Principle of pulleys is that, disregarding friction,
Input work = Output work.

The mechanical advantage of a machine is how many times it increases the effort force. It is expressed as the resistance force divided by the effort force. The formula is:

$$\text{M.A.} = \frac{\text{Resistance force}}{\text{Effort force}} \quad \text{or} \quad \text{M.A.} = \frac{R}{E}$$

The theoretical mechanical advantage of any machine can be calculated by dividing the distance that the effort force moves by the distance the resistance force moves.

$$\text{M.A.} = \frac{\text{Distance the effort moves}}{\text{Distance the resistance moves}} \quad \text{or} \quad \text{M.A.} = \frac{D_e}{D_r}$$

In machines that turn the mechanical advantage is calculated by dividing the length of the effort arm by the resistance arm.

$$\text{M.A.} = \frac{\text{Length of the effort arm}}{\text{Length of the resistance arm}} \quad \text{or} \quad \text{M.A.} = \frac{D_e}{D_r}$$

VOCABULARY

The vocabulary is not to be a technical vocabulary, but rather a utilization of student vocabulary that will allow easier understanding of the concept through verbalization. The following vocabulary will be written with the technical terms following the "coined terms" that are to be used as introductory terms in the classroom. It is important that the teacher introduce the technical term by casually interjecting the technical term into the discussion periods until there is a complete understanding of the term, then the technical term should be formally introduced and become a part of the students' vocabulary.

1.	Turning point	Fulcrum
2.	Pounds	Force (unit of weight)
3.	Bar	Lever
4.	Arm	Distance from the fulcrum to the point where the effort force or resistance force is attached.
5.	Resistance force	Weight of the object to be lifted.
6.	Effort force	Weight indicated by the spring scale.
7.	Turning	Movement around the turning point due to moments of force or torque.
8.	Balance	When arms are the same distance from the floor. Moments of force are equal and opposing; equilibrium.
9.	Straight up	Perpendicular direction.
10.	Scales	An instrument used to measure weight.
11.	Moment of force or torque	Product of a force times its distance from the turning point.

Topic 1 - The lever is a machine. The lever shows weight relationships.

SCIENTISTS INVESTIGATE EVERYTHING. THEY PLAY WITH ANYTHING THEY CAN GET THEIR HANDS ON. IT SEEMS THAT BY LOOKING AND MEASURING WHAT THEY SEE, THEY CAN FIND REASONS WHY SOME THINGS HAPPEN AS THEY DO. YOU HAVE DONE THE SAME THING MANY TIMES. FOR EXAMPLE, HOW MANY MACHINES HAVE YOU SEEN THIS WEEK?

List all responses on the overhead projector. Do not expect an immediate response. Also ask "How does it work?" Emphasis should be on leverage, turning, force, and work. These emphases will have to be made by the teacher as supporting remarks.

Place on the overhead projector a prepared acetate of a shovel, door, rocking chair, jack, hammer (pulling a nail), and a bar picking up a rock (first class lever). The discussion should compare the items to a bar; stress the point of turning. Emphasize the meaning of work while casually inserting the terms force and weight.

Topic 1 (continued)

HOW ABOUT YOU, ARE YOU A MACHINE? (Discussion) WHAT IS A MACHINE? (List all replies on the overhead projector). FROM OUR DISCUSSION WE CAN DEFINE A MACHINE AS SOMETHING THAT DOES WORK. SO TURN AROUND AND SHAKE HANDS WITH A FELLOW MACHINE.

LET'S TALK ABOUT YOUR ARM MACHINE. HOLD YOUR ARMS OUT STRAIGHT OUT TO THE SIDE OF YOU. (Teacher demonstrates). NOW MOVE FROM SIDE TO SIDE THREE TIMES AND COME BACK TO BALANCE (While arms are still straight out). WHAT WOULD YOU SAY BALANCE IS WHEN YOUR ARMS ARE AS THEY ARE NOW, MR. MACHINE? (Get one or two statements then tell the students to rest their arms.)

Discuss the idea of balance until the definition of balance is well understood by giving other examples (carpenter's level, see-saw, et. al.). LET'S DEFINE BALANCE AS WHEN ARMS ARE THE SAME DISTANCE FROM THE FLOOR. ANY ONE HAVE ANY OBJECTIONS?

Pass out sheet A - 1.

TEACHER DIRECTION A - 1

THE EFFECT OF WEIGHTS ON THE LEVER

Let the students voluntarily group themselves into groups of three. Materials for groups of three:*

1. Bar (one inch dowling, 36" long, with 2 holes, at 9 and 18 inches)
2. Two wire hooks (to be used as hangers for washers)
3. Pin (1/4 inch dowling, 12 inches long)
4. 5 washers (weights)

The purpose of this first activity is to determine the nomenclature of the lever and to familiarize the student with the equipment.

Place a prepared acetate of a bar, pin, hooks, and shoes (assembled) on the overhead projector. (Do not comment on this acetate).

THE SCIENTISTS GIVE EVERYTHING A NAME, SO LET'S NAME THESE ITEMS. O.K.? (Hold up a bar) WHAT IS THIS? (Discussion) LET'S CALL IT A BAR.

(Place the pin through the hole in the bar (middle) and spin the bar.) WHAT ARE WE GOING TO CALL THIS PLACE WHERE IT IS TURNING? (Discussion) LET'S CALL IT A TURNING POINT.

NOW WE HAVE TO CALL THIS PIN SOMETHING. (Discussion) LET'S CALL IT A PIN. (Discussion)

---

*These can be purchased at a hardware store: 1" dowling at 12 cents per foot; 1/4" dowling at 3 cents per foot; 1" flat washers (4 oz) at 7 cents each; 1/2" flat washers at 1 cent each (45 per pound).

Teacher Direction A-1 (continued)

BY USING THE HOOKS, BAR, AND THE PIN, FIND OUT WHICH OBJECTS ARE THE HEAVIEST AND DRAW YOUR RESULTS ON THE DIAGRAMS.

TEACHER DIRECTION A - 2

DETERMINING THE WEIGHT OF AN OBJECT

When the students have completed Activity 1, remind them to keep the hangers at the ends of the bar for this second activity. The sheet for activity 2 should be passed out after the completion of activity 1.

Topic 2 - Moving the turning point on the bar changes the force requirements to balance the lever.

THE IDEA OF BALANCE IS A COMPLICATED MATTER AND SCIENTISTS HAVE LEARNED MUCH MORE ABOUT IT. ONE THING THEY OBSERVED IS THAT THE TURNING POINT DOES NOT HAVE TO BE IN THE MIDDLE OF THE BAR TO BALANCE THE BAR.

HOW COULD YOU BALANCE A BAR IF THE TURNING POINT IS NOT IN THE MIDDLE?

The discussion should emphasize the weight relations and the length of the arms of the lever. Use in the discussion the words, arms, weight, force, turning point, and bar.

IF WHAT YOU SAY IS TRUE AND THE BAR CAN BE BALANCED WHEN THE TURNING POINT IS NOT IN THE MIDDLE, YOU SHOULD BE ABLE TO SHOW IT. SO SHOW IT WITH THE MATERIALS YOU HAD IN THE LAST ACTIVITY. DO YOU THINK YOU CAN? LET'S FIND OUT.

Pass out sheet A - 3.

TEACHER DIRECTIONS A - 3

THE LEVER WHEN THE TURNING POINT IS NOT IN THE MIDDLE

Materials for groups of three:

1. Bar
2. Two wire hooks
3. Pin
4. Weights (washers)

The students are to place the hooks on the ends of the bar, a shoe on the short end, and the weights on the long end, and then viss-versa. This is to introduce the idea of mechanical advantage. Mechanical advantage is not to be discussed at this time.

Student A - 1

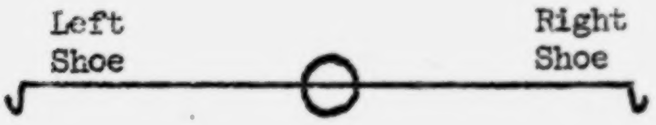
THE EFFECT OF WEIGHTS ON THE LEVER

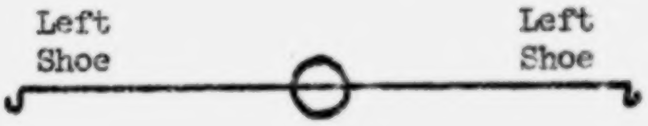
Materials for groups of three:

1. Bar
2. Two wire hooks
3. Pin
4. Five weights

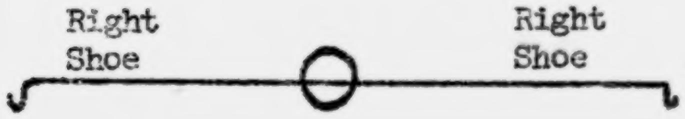
The balance can be used to find out which objects such as shoes are heavier. The heavier shoe will cause the bar to turn downwards and not be in balance. This idea of balance then can be a useful tool for finding out how much something weighs.

The bar, pin, and hooks are to be used to determine which shoes weigh more. The results are to be drawn on the diagrams below. If you do not understand, ask your instructor.





Which is heavier_____________ Which is lighter_______________



Which is heavier_______________

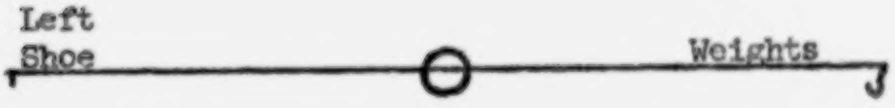
When you have completed this activity, obtain A - 2 from your instructor.

Student A - 2

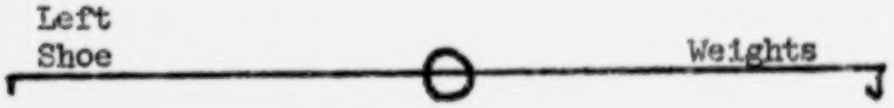
DETERMINING THE WEIGHT OF AN OBJECT

Now that Activity 1 is completed, obtain weights from the instructor and find out how much the shoes really weigh. Be sure that the books are placed on the end of the bar.

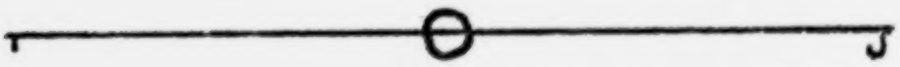
Find out how much the shoes weigh by using washers to balance the bar. The results are to be drawn on the diagrams below. How many washers does the shoe weigh? Weight may be expressed by the number of washers as well as in pounds or ounces.



Number of weights_______.

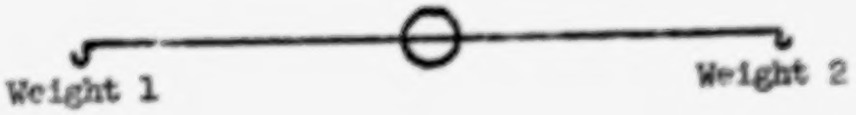


Number of weights_______.



Number of weights_______

EXAMINATION A - 1 and A - 2



Set up a demonstration using the bar, pin, hooks and various objects as weights, to determine which of the objects is heavier. Use the drawing above as a guide. After finding out which one is heavier, answer the questions below.

1. Is the bar in balance after putting the weights on the ends of the lever?

2. Is weight number 1 heavier than weight number 2?

3. Is the turning point in the middle?

Teacher instructions:

Have each group to reassemble their apparatus for A-1 and A-2. Then proceed with the examination by asking leading questions to each group while circulating among the groups. Insure success through discussion with each group. After the small group discussions, instruct the students to write the answers to the questions independently stating the reasons why they answered the above questions as they did.

Teacher directions A-3 (continued)

SCIENTISTS HAVE FOUND OUT THAT THE BAR HAS TWO DIFFERENT TYPES OF USES WHEN THE TURNING POINT IS NOT IN THE MIDDLE OF THE BAR. THE NUMBER OF WEIGHTS NEEDED TO BALANCE THE SHOE IS VERY DIFFERENT WHEN THE SHOE IS AT DIFFERENT ENDS. YOU ARE TO FIND OUT ON WHICH END THE SHOE SHOULD BE PLACED, AND THE NUMBER OF WEIGHTS NEEDED TO BALANCE THE BAR WHEN THE SHOE IS PLACED ON EITHER END OF THE BAR. I THINK YOU ALREADY KNOW, BUT YOU MUST SHOW IT.

Place a prepared acetate on the overhead projector showing the shoes and weights in the correct places, but do not mention it to the class.

After A - 3 is completed, the class is to reassemble for a discussion of results and principles using a prepared acetate. The introduction of the term DATA is to be used but not stressed. The terms DATA and INFORMATION can be used interchangeably. There should be no effort made to force the term data, but make repeated use of the term both verbally and in written form.

This discussion will be centered around the instructor who is verbally asking for results in the large group and writing the data on the overhead projector. Use no structured approach, but from a voluntary recitation gather data.

THE INFORMATION CONCERNING SHOES SHOULD BE PLENTIFUL. WITH YOUR BAR YOU HAVE WEIGHED THEM MANY TIMES AND COLLECTED A LOT OF DATA TO GIVE YOU THIS INFORMATION. SO LET'S FIND OUT WHO HAS THE HEAVIEST SHOE AND WHO HAS THE LIGHTEST SHOE.

Using a prepared acetate as shown below, record all data. You may question the validity of some of the results, but record them anyway. If students question it, encourage questioning and ask for proof by taking time to perform the needed test to prove it. The selection of students to perform the activities in front of the class should reflect good judgement. It will be necessary to use the lever of the group in question. If unable to select a student, then the teacher should demonstrate by setting up a lever. If students fail to question the validity of certain results then the teacher should encourage questions concerning the validity by asking leading questions.

For overhead projector

DATA ON SHOES

Group Number	Heaviest shoe	Lightest shoe
1		
2		
3		
4		
5		

Teacher Direction A - 3 (Continued)

After the heaviest shoe and the lightest shoe have been selected the discussion should lead into mechanical advantage. The important idea to stress is that in leverage it makes a great deal of difference when you change the position of the turning point. This should be obvious to the students at this point but a verbal acknowledgement should be given. This can be accomplished by referring to a car stuck in the sand and the use of a large pole as a lever.

YOU KNOW IT MAKES A LOT OF DIFFERENCE WHERE THE SHOE IS LOCATED ON THE BAR. IF IT IS ON THE SHORT END OF THE BAR YOU CAN MOVE IT MORE EASILY, BUT IF IT IS ON THE LONG END OF THE BAR IT ISN'T AS EASY TO MOVE. RIGHT?

(A short discussion will establish this point.)

THERE IS A DEFINITE ADVANTAGE IN KNOWING ON WHICH END TO PLACE THE OBJECT YOU WANT TO MOVE. FOR EXAMPLE, IF YOUR CAR WAS STUCK AND ALL YOU NEEDED TO DO WAS LIFT ONE WHEEL, AND YOU HAD A LONG POLE, HOW WOULD YOU GET THE CAR OUT?

(Other examples can be used. How would a house mover lift the corner of a house?)

TEACHER DIRECTION A - 4

HOW A SCIENTIST WORKS

Materials for groups of three:

1. Bar 2. Pin

The following discussion should lead the class into a more scientific approach in investigating the lever. The crude bar had many inadequacies and these inadequacies when critically analyzed should reveal the need for better equipment and a more refined technique. The term FRICTION should be introduced as it applies to the fulcrum.

Pass out the bar and pin used in A - 3.

LOOK AT YOUR BAR AND MOVE IT VERY SLOWLY ON THE PIN. (The teacher should demonstrate both turning and sliding movement.)

NOW, LET'S CRITICIZE OUR RESULTS JUST LIKE A SCIENTIST WOULD. WHAT THINGS CAN YOU SEE THAT WOULD CAUSE YOUR RESULTS TO BE INACCURATE? (List all responses on the overhead projector.) Stress friction. State ways that it may be overcome. Encourage the need to provide equipment to overcome the inadequacies using references to the available equipment to be used in the following activity. An example would be the use of a thin edge in the place of the pin for the fulcrum.

Pass out A - 4.

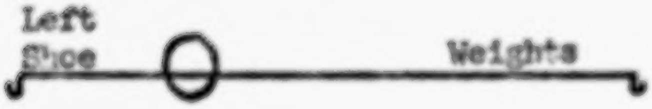
Student A - 3

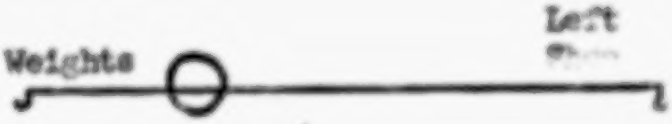
THE LEVER WHEN THE TURNING POINT IS NOT IN THE MIDDLE

Materials for groups of three:

1. Bar
2. Pin
3. Two wire hooks
4. Weights

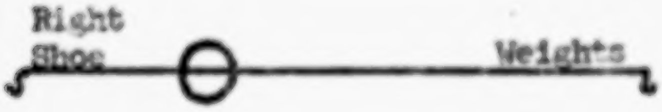
The balance can be used to find out how much objects weigh. You will know the number of weights needed when the bar is in balance. To balance the bar, place a shoe or the object to be weighed on one end and the weights on the other end. The difference in the number of weights needed is to be determined when the turning point is not in the middle of the bar. The results are to be drawn on the diagrams below. If you do not understand, ask your instructor.

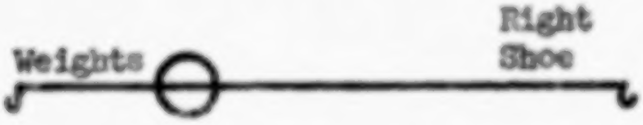

Left
Shoe
Weights


Weights
Left
Shoe

Number of weights__________

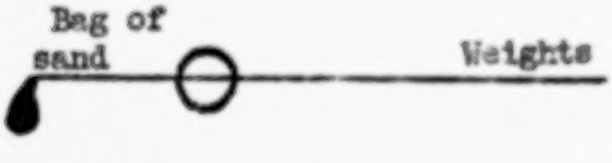
Number of weights__________

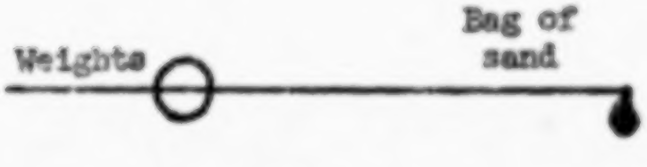

Right
Shoe
Weights


Weights
Right
Shoe

Number of weights__________

Number of weights__________


Bag of
sand
Weights


Weights
Bag of
sand

Number of weights__________

Number of weights__________

Heaviest shoe ....________weights

Lightest shoe ....________weights

Bag of sand ....________weights

Heaviest shoe ....______weights

Lightest shoe ....______weights

Bag of sand ....______weights

EXAMINATION A - 3

Situation test: The teacher reads the situation and questions to the class. The students are to use their own pencil and paper.

IF BIG JOHN AND LITTLE BILL WERE ON A SEE-SAW WITH THE TURNING POINT IN THE MIDDLE, THE SEE-SAW WOULD NOT BE IN BALANCE. (Conduct a free discussion, with the teacher providing leading questions to insure understanding. Use overhead projector illustrating the situation by a freehand drawing.)

1. WHO WOULD BE CLOSEST TO THE GROUND? (Teacher instructs the students to answer by telling who and why or how they know.)

2. WHAT WOULD HAPPEN IF BIG JOHN JUMPED OFF THE SEE-SAW? (Teacher instruction same as in question 1.)

3. IF LITTLE BILL JUMPED OFF THE SEE-SAW WHILE BIG JOHN WAS ON IT, WHAT WOULD HAPPEN? (Teacher directions same as in question 1.)

4. IF LITTLE BILL AND BIG JOHN BOTH JUMPED OFF THE SEE-SAW AT THE SAME TIME, WHAT WOULD HAPPEN? (Teacher directions same as in question 1.)

Teacher instruction:

This verbal test on A - 3 is to follow the class discussion after completing the activity.

Teacher direction A - 4 (continued)

The reading material should reinforce the above discussion. The teacher must relate the reading material to the activities.

The terms INTERPRETING and OBSERVATIONS in the reading material will be new words and must be clarified before the students begin reading.

The following discussion is to reinforce the reading material and give the students confidence in their reading ability. The teacher should commend the students whenever possible for getting so much out of their reading assignment.

DID THE READING MATERIAL BRING UP ANY QUESTIONS NOT DISCUSSED IN CLASS? (Discussion)

A short discussion of the points in the last paragraph of A - 4 will be needed if not initiated by the students. The discussion should introduce A - 5.

TEACHER DIRECTION A - 5

INCREASING ACCURACY WITH LEVERS

Materials for groups of three: (H.B.W. -12*, blue drawer, boxes 1 and 4)

1. 1 wood ruler
2. 1 hardboard 5" x 13"
3. 2 slotted hardboard supports
4. 1 plastic tube
5. 1 fulcrum bracket (pin)
6. 1 lever holder
7. 2 bolts and nuts
8. 6 washers (weights)

The students are to follow teacher instructions in assembling their apparatus and not get ahead. The teacher should have a preassembled model.

ATTACH THE FULCRUM BRACKET TO THE HARDBOARD WITH THE TWO BOLTS AND NUTS. (The teacher should show the position on the assembled model for all steps.) NEXT, ATTACH THE SLOTTED HARDBOARD SUPPORTS TO THE HARDBOARD AND INSERT THE PLASTIC TUBING FOR STABILITY. Pause. NEXT SLIP THE METAL LEVER HOLDER ON THE RULER IN THE MIDDLE AT ZERO. MAKE SURE YOU DO NOT GET IT UPSIDE-DOWN. NOW PLACE THE LEVER BRACKET ON THE FULCRUM BRACKET. Pause. IS IT IN BALANCE?

PLACE A WEIGHT ON THE LEFT SIDE OF THE BAR SO THAT YOU CAN SEE THE NUMBER 10 THROUGH THE HOLE. Pause. IS YOUR BAR IN BALANCE? (Discussion)

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* Harcourt, Brace and World, "Classroom Laboratory 6", Investigation No. 12.

HOW A SCIENTIST WORKS

The scientist writes and discusses what he finds with other people. This is his way of checking on himself. He asks people to tell the truth and to ask him many questions. If he can't answer the questions, then he tries to find out the answers. Usually, he returns to his laboratory and sits down to think about his problem and change his equipment to obtain more accurate information, or data. He knows that accurate information is necessary in order to understand the information or data.

After the scientist has obtained improved equipment, he then proceeds to do the experiment again. In the case of levers, he knows that balance is important. He knows that friction at the turning point is not good. He knows that all the measurements are very important and must be accurate. He knows the weights must be accurately counted. He investigates to find the answers to questions by observations, by recording data, and by interpreting data. He attempts to be careful in gathering his data so that his conclusions will be dependable.

Teacher Direction A - 5 (continued)

PLACE ANOTHER WEIGHT ON THE RIGHT SIDE OF THE BAR SO THAT YOU CAN SEE THE NUMBER 10 THROUGH THE HOLE. IS YOUR BAR IN BALANCE? Pause. HOW DO YOU KNOW?

PLACE A WEIGHT ON THE LEFT SIDE OF YOUR BAR SO THAT YOU CAN SEE THE NUMBER 6 THROUGH THE HOLE. IS YOUR BAR IN BALANCE? (Discussion)

PLACE ANOTHER WEIGHT ON THE RIGHT SIDE OF THE BAR SO THAT YOU CAN SEE THE NUMBER 7 IN THE HOLE. IS YOUR BAR IN BALANCE? Pause. HOW DO YOU KNOW? (Discussion) WHERE SHOULD THE WEIGHT ON THE RIGHT SIDE BE PLACED FOR THE BAR TO BALANCE? (6) (Discussion)

PLACE TWO WEIGHTS ON THE LEFT SIDE ON NUMBER 5 AND TWO WEIGHTS ON THE RIGHT SIDE ON NUMBER 5. IS YOUR BAR IN BALANCE? (Discussion)

Pass out A-5.

NOW LOOK AT SHEET A-6. FOLLOW THE DIRECTIONS AND COMPLETE THE ACTIVITY. (Discussion)

Topic 3 - A moment of force is the force times the distance from the turning point.

TEACHER DIRECTION A - 6

MOMENTS OF FORCE

Materials for groups of three: Same as for A - 5.

This activity will introduce the term and concept of 'moment of force', but the term is not to be stressed at this time.

Pass out A - 6.

ASSEMBLE YOUR APPARATUS THE SAME WAY YOU DID IN A-5. FOLLOW THE SAME PROCEDURE USING THE INFORMATION GIVEN IN THE TABLE AND DETERMINE THE POSITION THAT BRINGS THE LEVER INTO BALANCE. RECORD YOUR RESULTS UNDER POSITION ON THE RIGHT SIDE OF THE TABLE.

Demonstrate procedure and record the first line of the table on the prepared acetate. Instruct the students to obtain data to complete the table.

After all equipment has been disassembled and returned, complete the table on the overhead projector with the students in a large class discussion letting the students supply the answers.

HOW DID YOUR EQUIPMENT WORK? (Discussion.) WAS IT BETTER THAN THE FIRST BAR? (Discussion)

Student A - 5

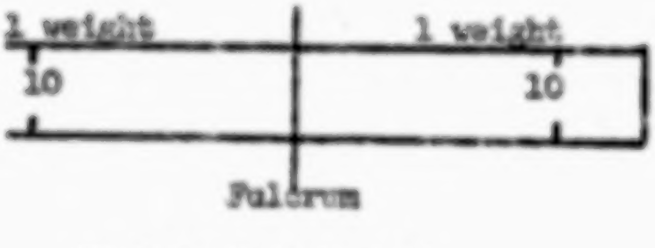
INCREASING ACCURACY WITH LEVERS

Materials for groups of three:

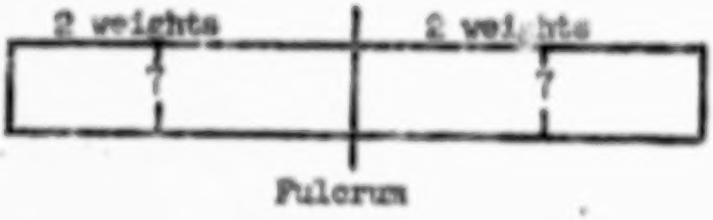
1. 1 wood ruler	5. 1 plastic tube
2. 1 hardboard (5" x 13")	6. 1 lever holder
3. 2 slotted hardboard supports	7. 2 bolts and nuts
4. 1 fulcrum bracket (pin)	8. 6 weights

Attach the fulcrum bracket to the hardboard with the two bolts and nuts. Next, attach the slotted hardboard supports to the hardboard and insert the plastic tubing for support. Next, slip the metal lever holder on the ruler in the middle at 0. Make sure you do not get the ruler in the up-side-down way. Now place the lever on the fulcrum bracket. The lever should now be in balance.

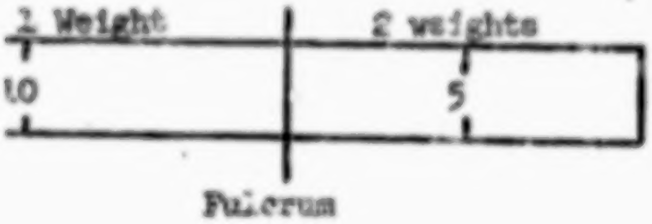
Place the weights on the numbers indicated in the drawings below and answer the questions. If you do not understand, ask your instructor for help.


1 weight
1 weight
10
10
Fulcrum

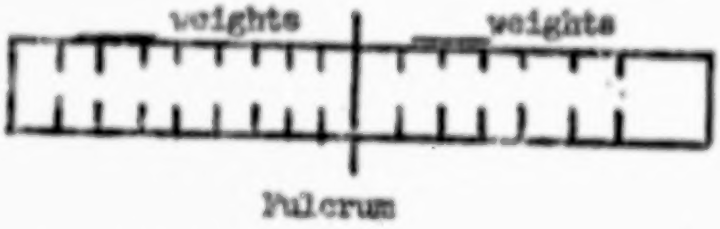
Is this in balance?__________


2 weights
2 weights
7
7
Fulcrum

Is this in balance?____________


1 Weight
2 weights
10
5
Fulcrum

this in balance?____________


weights
weights
Fulcrum

Is this in balance?____________

Teacher direction A - 6 (continued)

NOW LET'S TRY TO INTERPRET THE DATA. WHAT CAN YOU FIGURE OUT FROM THE TABLE? (If the blank space is not mentioned, call it to their attention.) LET'S FILL IN THE BLANK COLUMN ON THE LEFT SIDE AND THE RIGHT SIDE OF THE TABLE. ON THE FIRST LINE, LET'S MULTIPLY THE NUMBER OF WEIGHTS COLUMN TIMES THE POSITION COLUMN AND RECORD THE ANSWERS IN THE BLANK SPACES. FIRST, MULTIPLY 2 TIMES 6. Pause. WHAT DID YOU GET? (12) RECORD THAT NUMBER IN THE BLANK SPACE. (Discussion) NOW MULTIPLY 2 TIMES 6 ON THE RIGHT SIDE. Pause. WHAT DID YOU GET? (12) RECORD THAT NUMBER IN THE BLANK SPACE. (Discussion) Complete the chart in a similar manner. DO YOU KNOW WHAT SCIENTISTS CALL THESE RESULTS IN THE BLANK SPACES? Pause. MOMENTS. SO WRITE MOMENTS IN THE CHART. (Discussion)

The following discussion is to develop the "if - - then" approach to learning. Instead of "if - then", the term "would you believe" may be used.

Instruct the students to get a pencil and sheet of paper.

WOULD YOU BELIEVE, THAT IF TWO WEIGHTS WERE ON 5 ON THE LEFT SIDE, THE MOMENT WOULD BE 10. YES. (Using the overhead projector, make sure the students understand the procedure.) Then make this a game by asking the students to pose questions. You may have to give several more examples and the students may not choose to ask questions readily, but be persistent and try to make it into a game.

WOULD YOU BELIEVE, THAT THE MOMENTS WOULD BE EQUAL AND THE BAR WOULD BE IN BALANCE, IF THERE WERE TWO WEIGHTS ON 5 ON THE LEFT SIDE, AND ONE WEIGHT ON 10 ON THE RIGHT SIDE. Develop this by using the same procedure as above.

TEACHER RESOURCE A - 7

DETERMINING MORE COMPLEX MOMENTS

This activity is to develop the concept of total moments of force. The total moments of force can be determined by adding the moments on each side of the lever. The total clockwise moments must equal the total counterclockwise moments to produce equilibrium or balance.

Student A - 6

MOMENTS OF FORCE

Materials for groups of three:

Same as A - 5.

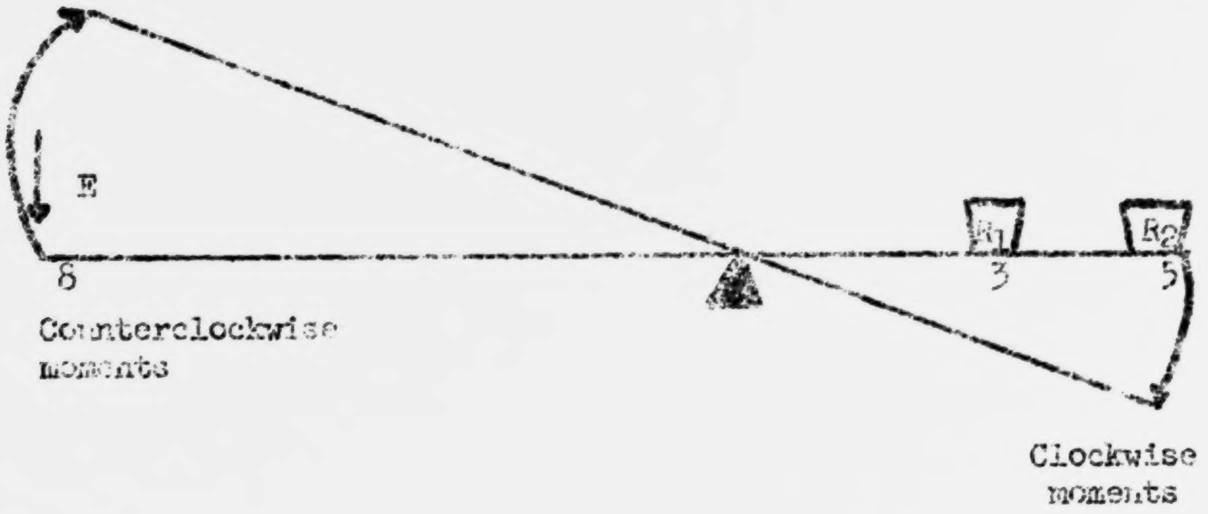
Many scientists use the same method for solving a problem. First, they determine what questions need to be answered and then they try to think of some possible answers. Next, they experiment, collect data, and place it in a table similar to the one below. Then they try to answer their questions from the information recorded in the table and by discussing it with other scientists.

Complete the table below by filling in the column left blank under "Position" on the right side by experimentation. Remember, your lever must come to balance.

LEFT SIDE			RIGHT SIDE		
Number of weights	Position		Number of weights	Position	
2	6		2		
2	6		1		
3	4		2		
3	5		1		
3	3		1		
2	6		4		
4	4		2		
1	12		3		

After completing the experiment, take your apparatus apart and return it to the proper place.

Teacher resource A - 7 (continued)



If each force (E) = 1 weight (washer) :

Counterclockwise	=			clockwise
E x D (effort)	=	R x D	+	R x D (resistance)
moment	=	moment	+	moment
1 x 8	=	1 x 3	+	1 x 5
8	=	3	+	5
8	=		8	

The lever is therefore in balance.

The direction in which the force is being exerted determines whether it is a clockwise or counterclockwise moment.

TEACHER DIRECTION A - 7

DETERMINING MORE COMPLEX MOMENTS

Materials for groups of three: Same as for A - 6.

ASSEMBLE YOUR APPARATUS THE SAME WAY YOU DID IN A-6. DO NOT BEGIN THE EXPERIMENT UNTIL ALL HAVE COMPLETED ASSEMBLING THE APPARATUS. WE WILL WANT TO DO THE FIRST COUPLE OF PROBLEMS TOGETHER. SO, DO NOT BEGIN UNTIL ALL ARE READY.

Pass out A-7.

Teacher direction A - 7 (continued)

The students are to follow along with their apparatus as the teacher demonstrates on the overhead projector with the prepared acetate. While leading a discussion, make sure all are following your instructions. The students are to follow the demonstration diagram on the first page of A-7. After completing the demonstration, have the students complete the table on the second page of A - 7.

After the apparatus has been disassembled and replaced, begin the discussion of the activity in the class group using the overhead projector and a prepared acetate of the table. The students should have pencil and paper for calculations.

NOW, LET'S LOOK AT THE TABLE AND TRY TO INTERPRET THE DATA. WHAT CAN YOU FIGURE OUT FROM THE TABLE?

If the blank space is not mentioned, call it to the students' attention. The teacher should proceed to fill in the table as in A-6. Some acting by the teacher will be necessary to dramatize the relationships of moments of force. In this discussion, the term MOMENTS OF FORCE should be used freely. Compliment student usage of the term.

The following discussion is to develop the "if - then" approach to learning. Instead of "if - then", the term "would you believe" may be used.

"WOULD YOU BELIEVE", THAT IF ONE WEIGHT WAS PLACED ON THREE AND ONE WEIGHT WAS PLACED ON FIVE ON THE SAME SIDE, THEN THE MOMENTS ON THAT SIDE WOULD BE EIGHT. Yes. Proceed with individual calculations followed by demonstrations using the overhead projector and a preassembled apparatus. WOULD YOU BELIEVE, THAT FOR BALANCE, THE MOMENT OF FORCE ON THE OPPOSITE SIDE WOULD HAVE TO BE EIGHT? Yes.

You may have to give several more examples to encourage students to pose similar questions, but be persistent and try to make it into a game. Attempt to get all the students to participate. Explain the use of the terms clockwise and counterclockwise to designate the direction of rotation of the lever.

WOULD YOU BELIEVE, THAT IF TWO WEIGHTS WERE PLACED ON 4 ON THE LEFT SIDE, THAT THE COUNTERCLOCKWISE MOMENTS OF FORCE WOULD BE 8? Yes. (Discussion).

"WOULD YOU BELIEVE", THAT IF ONE WEIGHT WAS PLACED ON 4, AND ONE WEIGHT WAS PLACED ON 6 ON THE RIGHT SIDE OF THE LEVER, THAT THE LEVER WOULD BALANCE IF TWO WEIGHTS WERE PLACED ON 5 ON THE LEFT SIDE OF THE LEVER? Yes.

Student participation and demonstration on a preassembled apparatus will be necessary. Have them identify the clockwise and counterclockwise moments. Have the students, as a group, suggest several combinations to further investigate moments. Or small groups may develop their own table and then test their predictions.

STUDENT

A - 7

DETERMINING MORE COMPLEX MOMENTS

Materials for groups of three:

Same as A - 6.

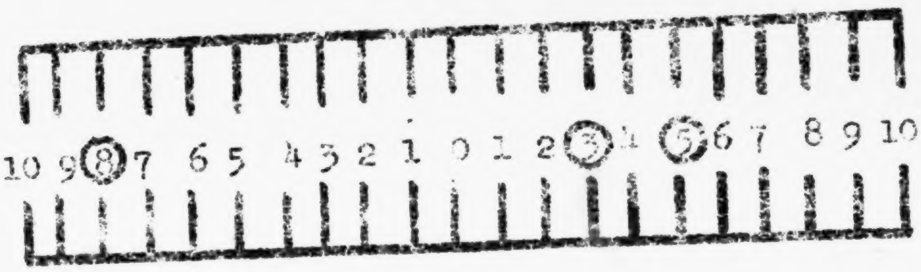
In our earlier discussions, we found out that when the lever was in balance, the moments of force on the left side were the same as the moments of force on the right side. Remember how you found out what the moments were? You just multiplied the distance of the weights from the turning point times the number of weights. It seems, then, that the moments determine when things are in balance; they must be the same on each side.

But, what would happen if we had more than one weight on one of the sides? If the lever is in balance, the moments on both sides must still be the same.

Let's collect some data using your apparatus and find out more about moments. Obtain the data and complete the table on the second page of A-7 by filling in the column under 'Moment' on the left and right side. Remember, your lever must be in balance to obtain accurate data.

To help you understand the table, your instructor will work the first one with you using the diagram below.

Demonstration for Moments of Force



STUDENT A - 7

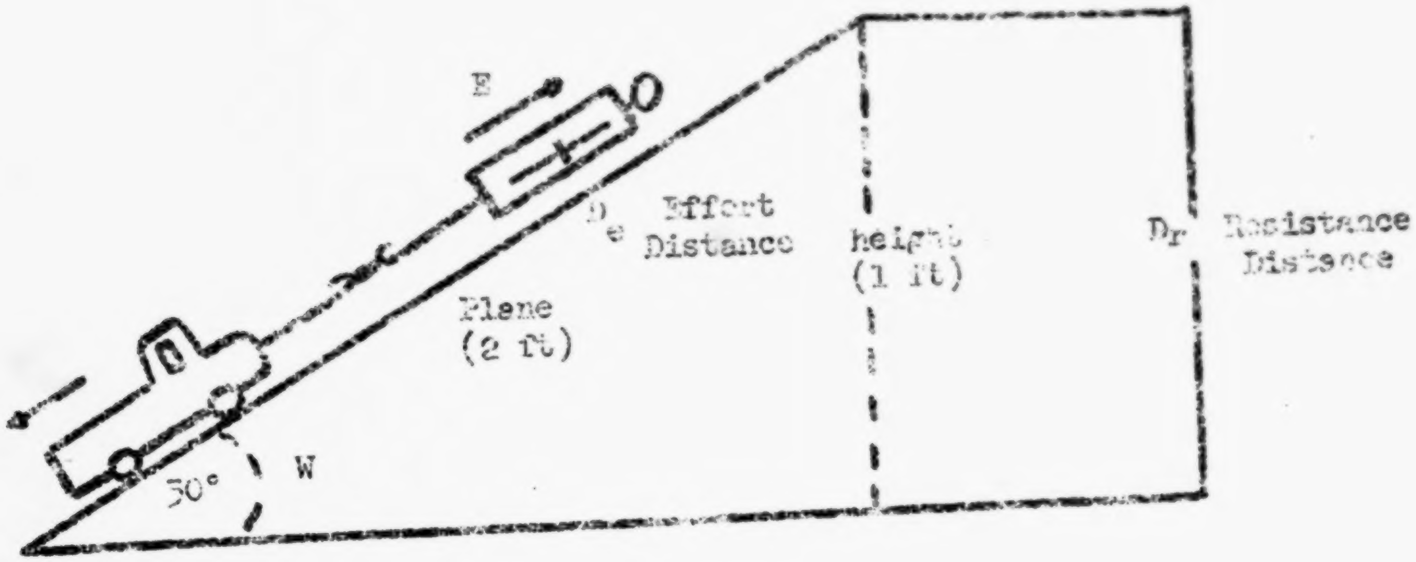
Page 2

Moments of Force

Number	Left Side			Right Side		
	Weight	Position	Moment	Weight	Position	Moment
1	1	8		1	3	
	xxx	xxx	00	1	5	
	▨	▨		▨	▨	
2	1	10		1	7	
	xxx	xxx	00	1	3	
	▨	▨		▨	▨	
3	1	4		1	12	
	1	3		xxx	xxx	00
	▨	▨		▨	▨	
4	1	14		1	6	
	xxx	xxx	00	1		
	▨	▨		▨	▨	
5	1	13		1	5	
	xxx	xxx	00	1		
	▨	▨		▨	▨	
6	1	3		1		
	1	5		xxx	xxx	00
	▨	▨		▨	▨	
7	1	5		1		
	1	9		xxx	xxx	00
	▨	▨		▨	▨	
8	1			1	3	
	xxx	xxx	00	1	6	
	▨	▨		▨	▨	

UNIT 2 INCLINED PLANE

TEACHER RESOURCE



1. An inclined plane is a flat surface raised at one end.
2. An inclined plane makes it possible to apply less force over a greater distance. But the total amount of work remains the same.
3. The forces acting on the resistance are balanced when the resistance is not moving. Work is equal to force times distance. When the resistance is not moving the distance is 0, therefore, the work is 0.
4. The formulas for mechanical advantage are:

$$\text{M. A.} = \frac{\text{Actual weight of resistance (W)}}{\text{Effort force (E)}} \qquad \text{(Actual M. A.)}$$

$$\text{M. A.} = \frac{\text{Length of plane } (D_e)}{\text{Height of plane } (D_r)} \qquad \text{(Ideal M. A.)}$$

5. Friction will account for a small experimental error.
6. The incline is the angle between the plane and the horizontal surface. In the laboratory activity an angle of 30° will be used.

$$\text{M. A.} = \frac{2}{1} = 2$$

Topic 1 - Work is the product of the force times the distance.

The concept of 'work' and of 'machine' must be developed to understand the inclined plane. Think of the human body as a machine.

MR. MACHINE, CAN YOU DO ANY WORK? (Discussion.) WHAT IS WORK? (Discussion) CAN YOU DO WORK WITHOUT EXERTING A FORCE? (Discussion)

Should the question of mental fatigue arise, limit the discussion to physical rather than biological measurements. Biological measurements will be studied later, but explain that mental acitivity is definitely tiring.

DO YOU HAVE TO MOVE SOMETHING TO GET WORK DONE? Yes. (Discussion) WE HAVE AGREED THAT BOTH FORCE AND DISTANCE ARE NECESSARY TO DO WORK. SCIENTISTS SAY THAT WORK IS FORCE TIMES DISTANCE.

Write on the overhead projector "Work = Force times Distance". SO, LET'S DO SOME WORK. (Instruct a student to push on a wall.) IS HE DOING ANY WORK? No. (Discussion) WHY? (Discussion) SOMEBODY DRAG HIM A CHAIR. (Do not let the student carry the chair.) (While dragging the chair), IS THE CHAIR DRAGGER DOING ANY WORK? Yes. (Discussion) WHY? (Discussion) HOW MUCH FORCE WAS EXERTED? (To determine the force, drag the chair with a large spring balance.)

Have several students measure the distance the chair was dragged. Calculate the work using the overhead projector. Do other experiments if requested.

TEACHER DIRECTION A - 8

WORK

Materials for groups of three:

1. Ruler

Materials for the class:

1. Bathroom Scale
2. Large spring balance

Formal instructions by the teacher have been omitted in this activity.

Pass out sheet A - 8.

Using the overhead projector and a prepared acetate, calculate and record the data needed to complete the chart for A-8. The first three problems will show a definite relationship as the weight remains the same and the distance increases by one. The work will increase as the distance increases while the weight remains the same.

Teacher direction A - 8 (continued)

The term foot-pounds is introduced at this point and should be used in the discussion freely. Try to get the students to use the term, but do not force its use. Explain that foot-pounds is the unit in which work is measured. It is appropriate and "makes sense" since you multiply feet times distance. Note that all formulas are written out. Past experiences with formulas have shown that the only symbol which one can use successfully is the equal (=) sign.

LET'S COMPLETE THE CHART TOGETHER, IF YOU HAVE ALREADY COMPLETED YOURS, CHECK YOUR RESULTS.

Ask for weights of the books at random and list one of the answers in the weight column, then solve the problem on the side of the acetate. Explain every step to the students. It is suggested you work the first problem with everyone paying attention, then ask the students to get out scratch paper and work the remaining problems with you. This is a good place to check the students' mathematics. Be sure to recognize success whenever possible.

LET'S LOOK AT THE FIRST NUMBERS IN THE WORK COLUMN AND THE FIRST NUMBERS IN THE DISTANCE COLUMN. CAN YOU SEE ANYTHING THAT SEEMS TO BE INDICATED? (Discussion) As the distance increases, the amount of work increases.

The relation of force, weight and work should be pretty well understood. Play the "would you believe" game. "WOULD YOU BELIEVE", THAT IF A MAN WEIGHS 150 POUNDS, AND IS LIFTED 2 FEET, THAT THE WORK DONE WOULD BE 300 FOOT-POUNDS. Yes. Solicit problems from the class.

"WOULD YOU BELIEVE", THAT IF THE AMOUNT OF WEIGHT INCREASED AND THE DISTANCE MOVED INCREASED, THE AMOUNT OF WORK WOULD INCREASE. (Discussion) Solicit verbal work problems as above from the class.

Topic 2 - The inclined plane is a flat surface raised at one end.

SCIENTISTS USE THE TERM "FORCE", MEANING WEIGHT, AND DETERMINE FORCE BY USING SCALES OR SPRING BALANCES AS YOU DID IN THE LAST ACTIVITY. BUT WE HAVE LOOKED AT ONLY TWO KINDS OF FORCES, THE EFFORT FORCE AND THE RESISTANCE FORCE. WHAT IS THE DIFFERENCE IN THE TWO FORCES? (Discussion)

The discussion should be very clear as to the relation of the effort force and the resistance force. The resistance force is related to the resistance, and the effort force is related to the effort. It should also be brought out that the resistance force acts in a direction opposite to the effort force. This will be very important in understanding the inclined plane. A good example is when the boy dragged the chair across the room. Friction should be discussed. It should be stressed that it should be reduced before using a machine to do the work. In the following activities, friction will account for some of the experimental error.

Topic 2 (continued)

LET'S THINK OF SOME WAYS THAT THE EFFORT FORCE MAY BE REDUCED TO LIFT SOME OBJECT, OR RESISTANCE. (Discussion) Levers will be mentioned but tell the students to try to think of another way. If the inclined plane is not suggested, give an example of how a man on a wheel chair gets into a house by building a ramp or inclined plane. A car going up a hill is another example.

IF A ROAD BUILDER WAS BUILDING A ROAD IN THE DESERT AND WANTED TO BUILD A BRIDGE OVER A RAILROAD TRACK, HOW COULD HE DO IT? (Discussion) Make the point that the flat surface of the road would be raised to form an inclined plane. It would be impractical to build an elevator or use a lever. An ax blade and a knife are other examples. The point to stress is that the weight of the object does not change, but the amount of effort force required to cause movement or balance does change.

Pass out A - 9

TEACHER DIRECTION A - 9

INCLINED PLANE

Materials for groups of three: (HBW - Blue drawer)

1. Ruler
2. Spring Balance
3. Two 4 ounce weights
4. Inclined plane
5. Truck

The inclined plane can be constructed by the students from scrap materials from a wood shop. The plane should be at least four inches wide.

The teacher should demonstrate the inclined plane and also show how it works using a prepared acetate. Then the equipment should be issued for the students to assemble prior to a discussion of the procedures. The students do not record data at this time. A trial run by the students is advisable before they start collecting and recording data. Hall's carriages and other inclined planes may also be used in addition to the toy trucks if interest is adequate.

Advise the students to round-off the numbers representing the forces to the nearest ounce. A demonstration may be necessary. Use of the truck to show how to round-off is advisable. It should also be recognized that the spring balances are inaccurate which will account for some of the experimental error.

After demonstrating the proper techniques, circulate among the groups helping them to succeed.

STUDENT

A - 8

WORK

Material for groups of three:

1. Ruler

A single word can have many meanings and can be used in many different ways. A good example is the word "cut". It can mean turn, such as "cut the corner", or it can mean stop when you say "cut it cut", or it can mean slice when you say "cut the butter". Scientists long ago recognized this problem and realized that something had to be done so that scientists everywhere would know what they meant when they used important words such as work.

Technically the word "work" is defined as "force times distance." This means that some force must be used to move an object some distance. If an object is not moved, then no work has been done.

Complete the table below by filling in the columns left blank. Remember, the force is measured with the spring balance, or the bathroom scales. Lift all objects straight up and measure the distance lifted.

WORK

OBJECT	DISTANCE feet	FORCE pounds	WORK foot-pounds
1 book	1 foot		
1 book	2 feet		
1 book	3 feet		
2 books	2 feet		
2 books	4 feet		
1 shoe	2 feet		
1 shoe	4 feet		
1 chair	1 foot		

Would it take more or less work to lift 10 pounds 2 feet than to lift 20 pounds 2 feet? Why? How much?

Teacher direction A - 9 (continued)

After completion of the activity, the students are to reassemble as a class for a discussion of the results. Using the prepared acetate of the chart, solicit results from the students and perform the required calculations.

Stress the point that, disregarding friction, the amount of input work is the same as the amount of output work. Even though the amount of work is the same, the effort force and distance vary. This can be shown by an analysis of the data after completing the chart. By questions, involve the students' participation in the analysis.

"WOULD YOU BELIEVE," THAT A BOY RUNNING TO THE TOP OF A BRIDGE WOULD DO THE SAME AMOUNT OF WORK BY CLIMBING A LADDER TO THE TOP OF THE BRIDGE.

Yes. It may be helpful to make a drawing of the inclined plane on the overhead projector. Some numbers may be needed (whole, simple numbers). The weight of one of the students may develop interest. Solicit and use problems from the class.

TEACHER DIRECTION A - 10

STAIRS AND WORK

Materials for the class:

1. Bathroom scales
2. 50 feet tape measure

The teacher should develop the idea that stairways are inclined planes. Steps are for human convenience only, but the plane remains and can be measured since the top of the stairs is higher than the bottom. This meets the definition of the inclined plane, that is, a relatively flat surface raised at one end.

"WOULD YOU BELIEVE," THAT A STAIRWAY IS AN INCLINED PLANE?

(Discussion) WHY? (Discussion)

SINCE WE KNOW THAT A FLIGHT OF STAIRS IS AN INCLINED PLANE, WOULD YOU BELIEVE, THAT A BOY RUNNING TO THE TOP OF THE STAIRS WOULD DO THE SAME AMOUNT OF WORK BY CLIMBING A LADDER TO THE TOP OF THE STAIRS, IF THE LADDER IS STRAIGHT UP? Yes. (Discussion) LET'S USE THIS KNOWLEDGE TO FIND THE EFFORT FORCE WE USE TO CLIMB A STAIRS.

Pass out the first page of A - 10.

Place the prepared acetate on the overhead projector for discussion of the instructions and procedures on the student sheet. Pass out page 2 after the completion of the first page.

After completing page 1 at the stairs, return to the classroom for calculations. On the prepared acetate, complete the table in detail with the class.

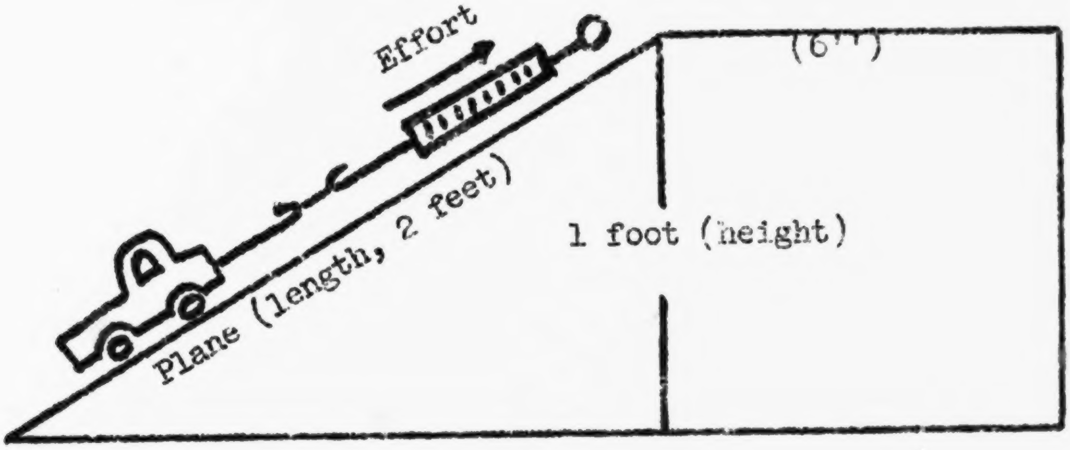
STUDENT

A - 9

INCLINED PLANE

Materials for groups of three:

1. Ruler
2. Spring Balance
3. Two 4 ounce weights
4. Inclined Plane
5. Truck



To a road builder and the driver of a car, the inclined plane is most important. To make the inclined plane, the road builder raises the flat surface of the road on one end. This causes an incline for cars to be driven up. As you know, how steep a hill is, or its incline, determines how hard it will be for the car to climb the hill. A very steep hill may prevent a car with low horsepower from climbing it, or it may be so hard to climb that traffic will move slowly near the top of the hill.

As you know, when you are moving something, you are doing work. You can find out how much work you are doing by multiplying the effort force, measured on the spring balance, times the distance the object is moved, that is the length of the plane. Work = effort force times the length of the plane. And of course, as you remember, work is also equal to the resistance times the distance the object is lifted. This gives you two ways to measure work. Let's find out if the work you do in pulling the truck up the inclined plane is equal to the work you do in lifting the truck the height of the plane. Is the effort force times the length of the plane, the same as the resistance force times the height of the plane?

Obtain an inclined plane and the other materials needed to find the answer to this question. Gather data and complete the table below by filling in the spaces left blank.

I. Work = Distance lifted (straight up) TIMES Resistance force (weight)
II. Work = length of inclined plane TIMES Effort force (spring balance, pulling)

Work: The Inclined Plane

OBJECT	DISTANCE height	RESISTANCE FORCE	WORK ft-oz	LENGTH plane	EFFORT FORCE	WORK ft-oz
Truck	1 foot	4 ounces		2 feet		
Truck and 1 weight	1 foot	8 ounces		2 feet		
Truck and 2 weights	1 foot			2 feet		

Is the amount of work the same in both case I and case II for the same object? If not, you need to check your work.

Try other objects if you want to.

Teacher direction A-10 (continued)

Page 2 of A-10 should not be given to the students until all have returned to the classroom. Do not stress the derivation of the formula, but answer all pertinent questions.

After discussing and working the problems as a class, each small group will choose one representative to weigh himself, and as a group of three, calculate the effort force required to climb the stairs. This is to be done on the bottom half of the second page of A-10.

Topic 3 - Power is the amount of work divided by the time.

TEACHER RESOURCE

$$\text{Power} = \frac{\text{Distance times Force}}{\text{Time}} = \frac{\text{Work}}{\text{Time}} = \frac{\text{Foot-Pounds}}{\text{Second}}$$

$$\text{Horsepower} = \frac{\text{Work}}{550 \times \text{Seconds}}$$

550 is the conversion factor
One H.P. = 550 ft-lb/sec.

WOULD YOU DO AS MUCH WORK WALKING UP THE STAIRS AS RUNNING UP THE STAIRS? (Discussion) WHY? Work is not a function of time. Power is a function of time.

TELL ME SOMETHING. WHY CAN SOME CARS ACCELERATE FASTER THAN OTHERS EVEN IF THEY WEIGH THE SAME? (Discussion) The term horsepower will be mentioned by the students. WHAT IS HORSEPOWER? (Discussion) HORSEPOWER IS THE AMOUNT OF WORK THAT AN AVERAGE HORSE CAN DO IN A CERTAIN AMOUNT OF TIME. HORSEPOWER IS JUST ONE OF MANY WAYS OF EXPRESSING POWER. SO LET'S TALK ABOUT POWER FIRST AND THEN HORSEPOWER. SCIENTISTS SAY POWER IS THE AMOUNT OF WORK DIVIDED BY THE TIME REQUIRED TO DO THE WORK. FOR INSTANCE, IF YOU LIFTED A 10 POUND SACK OF SUGAR 4 FEET IN 2 SECONDS, HOW MUCH POWER WOULD IT TAKE? (Write the formula on the overhead projector using words, notsymbols.) FIRST, LET'S DETERMINE THE AMOUNT OF WORK. (Calculate the work on the overhead projector using the acetate with the formula for power written on it for the next two items.) THIS IS THE AMOUNT OF WORK REGARDLESS OF HOW LONG IT TOOK TO DO THE WORK. (Discussion) NOW, DIVIDE BY THE TIME AND WE HAVE DETERMINED THE POWER. (Discussion) BUT WHAT IF IT HAD TAKEN FOUR SECONDS TO LIFT THE SACK OF SUGAR? HOW MUCH POWER WAS NEEDED? (Discussion) Play the 'would you believe' game soliciting problems from the class.

HOW MUCH POWER DO YOU HAVE? (Discussion) LET'S FIND OUT BY RUNNING UP SOME STAIRS.

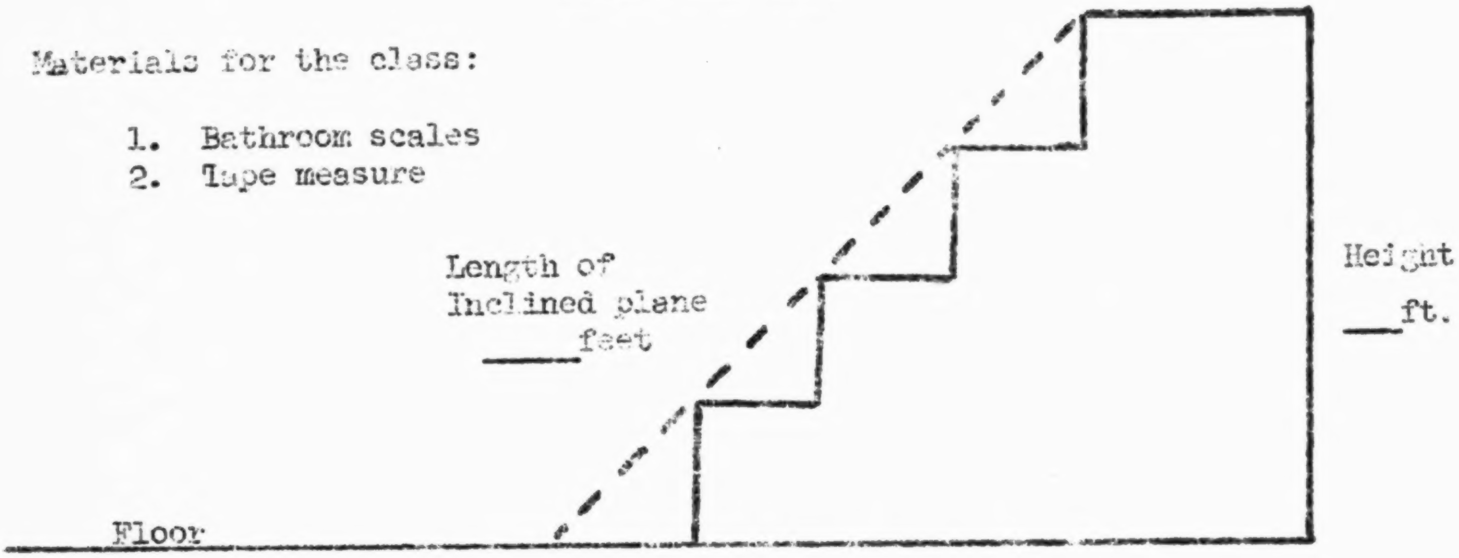
Pass out A-11.

STUDENT A - 10

STAIRS AND WORK

Materials for the class:

1. Bathroom scales
2. Tape measure



The above drawing is a diagram of some stairs. In this activity, you are to find out how much effort you exert when climbing stairs. It would be very difficult to measure the effort force needed to climb the stairs with a spring balance. So, let's do it another way.

You will need to know the weight of the object to be moved, in this case yourself, and the height you are to move. Remember, the weight of the object times the height equals the amount of work. So, let's determine the amount of work needed to climb the stairs. First, we will all go to the stairs as directed by your instructor. Each group will be assigned a number.

1. Group 1 measure the height of the stairs. Group 2 also measure the height of the stairs to see if Group 1 measured them correctly.
2. Group 3 will record the data for all measurements.
3. Group 4 measures the length of the plane from the floor to the top step. Group 5 will also measure the plane to check on Group 4.
4. Group 6 will supply a runner to run up the inclined plane (stairs). The runner will need to weigh himself on bathroom scales when he returns to the classroom. Group 7 should also have a runner.
5. Groups 8, 9 and 10 will be advisors. If any problems arise, these groups will solve them.

TEACHER DIRECTION A - 11

HUMAN POWER

The students are to use the same stairs for this activity as in A-10. Students should be instructed in stop watch procedures for timing. Give the students numbers representing the height and the length of the plane to write in on their drawing. Each student is to determine his own power which will require each student to weigh himself. Caution students about running up stairs too fast. Answer all questions, then proceed to the stairs where each group will run up the stairs in a predetermined order. Use descretion in excusing students due to individual personalities. These can be given associated jobs.

After completion of the activity return to the classroom for a class discussion of calculations. Have students who can, calculate his power prior to the class discussion. You can reinforce the calculation in the large group discussion. A few calculations of individual horsepower will be interesting, but the mathematics is too difficult for most of the students to perform alone. Proceed to the next activity in a short time.

Topic 4 - The application of horsepower as the basic unit of power.

TEACHER DIRECTION A - 12

HOW HORSEPOWER BECAME HORSEPOWER

The reading assignment is designed to develop interest in measuring horsepower. The words accomplish, calculate, transportation, device, centuries, Clydesdale horse (Budweiser's horses are this species), and strength should be explained before the reading assignment is passed out.

The calculations on the second page of A-12 can be discussed per se or may be calculated on the overhead projector. It is recommended that the calculation not be made unless requested by the students. The calculation is as follows:

$$\text{Horsepower} = \frac{2.5 \times 5280 \times 150}{3600 \times 550} = 10.1$$

The above calculation is based on 2.5 mi/hr, 5,280 ft/mi, 150 pounds of force (100 pounds effort force plus 50 pounds friction force) and 3,600 seconds per hour. Do not do the actual calculation until the students have read the assignment and then only if requested.

Pass out both pages of A-12.

TEACHER DIRECTION A - 13

HORSEPOWER TODAY

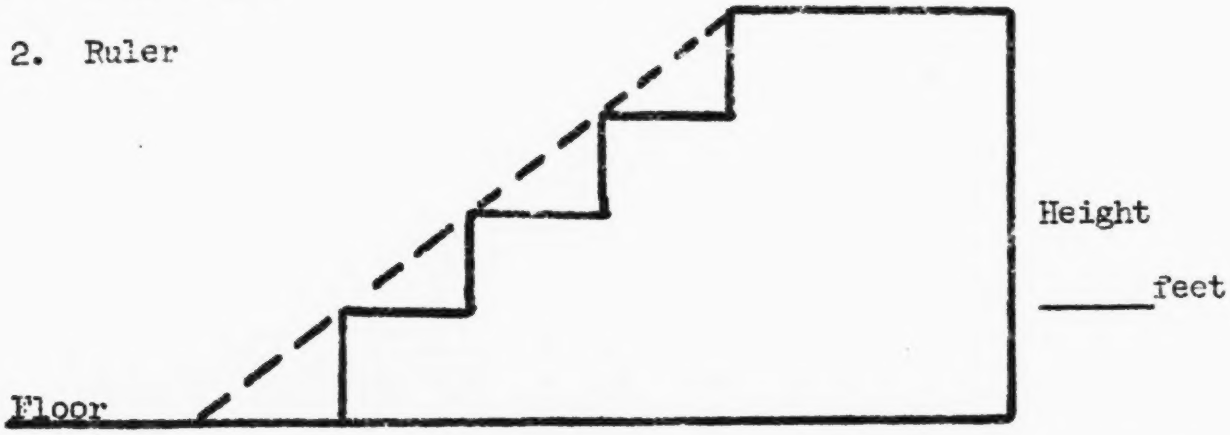
It is doubtful that the students will understand the calculation of horsepower, but with discussion and leading questions the teacher can promote some critical thinking and application. Attempt to get the students to relate this activity to their environment.

STUDENT A - 11

HUMAN POWER

Materials for groups of three:

1. Stop-watch
2. Ruler



Each student is to determine his own power. While one is running up the stairs, another member of the group is to use the stop-watch to time the runner. The third member is to stand at the top of the stairs to signal GO and STOP.

HEIGHT OF STAIRS	RESISTANCE weight of runner	WORK foot-pounds

Distance times Resistance = Work

WORK (from above)	TIME seconds	POWER $\frac{\text{foot-pounds}}{\text{seconds}}$

Work divided by Time = Power

Are you a very powerful machine?______________

Calculation of Effort

HEIGHT OF STAIRS	RESISTANCE Weight of runner	WORK foot-pounds

Distance times Resistance = Work

WORK (from above)	LENGTH OF PLANE feet	EFFORT FORCE pounds

Work divided by Length = Effort force

__________ foot-pounds

After completing the above table with your instructor, find out how much effort force is needed for one member of your group to climb the stairs. You should work together as a group on this problem. There should be three people in each group.

HEIGHT OF STAIRS	RESISTANCE Weight of runner	WORK foot-pounds

Distance times Resistance = Work

WORK (from above)	LENGTH OF PLANE feet	EFFORT FORCE pounds

Work divided by Length = Effort force

STUDENT A - 12

HOW HORSE POWER BECAME HORSEPOWER

It seems strange that in our age of jet planes and fast automobiles that scientists still measure power the same way they did during the period when horses were the main means of transportation. The history of horsepower is an interesting story. The real story could be called "How Horse Power Became Horsepower" in our world of progress and change.

Man first used simple machines to lift objects by using his own muscles to provide the force needed, but this would not allow him to accomplish all he wanted to accomplish. The wheel, levers, pulleys, as well as any other device he could think of were used, but still man was limited to his own energy. One day a man had an idea about his friendly animal standing next to him. The idea was to use the animal's strength along with his own; so animal power came into being. Through time man realized the horse was a fine animal to produce the force needed to accomplish the work. Many centuries and many hours of work were spent by men and horses in the history of man. The good horse may have been "man's best friend" for a long time, but now man's best friend may be a motor or an engine because the horse cannot compete with the modern day machines.

The beginning of man's use of fuel to develop power has a long and interesting history. An important event was the substitution of Mr. James Watt's mechanical steam engine to replace the faithful old horse. Mr. Watt was a Scottish engineer who lived from 1736 to 1819. He realized that steam engines were more powerful than the horse and tried to get coal miners to use the engine instead of horses to lift heavy buckets of coal and other objects. The men to whom Mr. Watt wanted to sell the engines were interested in knowing how many horses the machine would replace. To answer this question Mr. Watt started a scientific investigation to find out.

Mr. Watt observed two important factors. The first was that man became tired very quickly and therefore could not work at a steady pace. The second observation was that horses worked tirelessly at a steady pace for long periods of time. He decided to compare his steam engine to horses. Mr. Watt used a Clydesdale horse to walk round and round a wheel which was used to raise a 100 pound weight out of a deep well. He found that a horse could work over a long length of time at a speed of about 2 1/2 miles per hour while lifting the weight. The friction of the wheel was 50 pounds, so the horse was really lifting 100 pounds plus overcoming the friction of 50 pounds, or altogether 150 pounds. Mr. Watt knew that the power was equal to the number of feet moved times the weight divided by the time. The power of the horse was determined to be 550 foot-pounds per second, or 33,000 foot-pounds per minute. So Mr. Watt said, and everyone agreed, that the power of one horse will not be called horse power, but HORSEPOWER, and that 1 horsepower will equal 550 foot-pounds per second. The term horsepower is still used today as you know, and it really means "horse power". In other words, if your car has a 360 horsepower engine, it is the same power as 360 horses under the hood if you use Clydesdale horses as Mr. Watt did. Do you know why it must be Clydesdale horses?

Teacher direction A-13 (Continued)

The reference for the drawings is Brown and Schwachtgen, Physics: The Story of Energy, Heath and Company, Boston, 1954, pp 178-79. The formula for the calculation of horsepower for the electric motor is:

$$\text{Horsepower} = \frac{\text{Force times the Distance (circumference)}}{\text{Seconds for 1 turn times 550}}$$

$$= \frac{\text{275 pounds times 2 feet}}{\text{1 second times 550}} = \frac{550}{550}$$

$$= \text{1 horsepower}$$

The distance around the wheel can be measured with a tape measure or ruler or it can be calculated. It is recommended that measuring be stressed and not the calculation of the circumference. Perform the calculations only if the students show adequate interest. ($C = \frac{22}{7} D$)

The steam engine should be placed on the teacher's desk one day prior to passing out A-13 to create interest. The students will want to play with the steam engine. Answer all questions asked, but do not start the engine until after the students read A-13.

After discussing A-13 calculate the horsepower of the steam engine as discussed in the reading. Use a spring balance to determine the effort force. Measure the circumference of the wheel, and determine the time with a stop watch. This may be done as a class project or in groups, but let the students use the steam engine only after a procedure has been developed in the class discussion. It is important that the students be allowed to use the steam engine, but under direct supervision of the teacher.

All of A-13 should be read with the students aloud after the students have read it silently. The students should follow the reading while the teacher reads aloud. Explain each step and sentence. Encourage discussion at all times.

After completion of the activity, if the students wish to bring a bicycle into the classroom or bring motors from home for determination of horsepower, encourage it. For the bicycle, about 1/4 of the student's weight will be the effort force. (The tire on the bicycle wheel moves about 4 times as far as the feet do on the pedals. So the tire would push backwards with a force only 1/4 as great as the weight of the rider. The mechanical advantage of the combined machines in the bicycle is one-fourth.) The distance will be the circumference of the rear wheel, and the time will be the number of seconds it takes the student to go the distance of the circumference of the rear wheel. It will be necessary to go outside for this activity. The distance can be marked off by using chalk and then timing the student riding the bicycle. This activity will permit extensive individual investigations. Encourage this and pursue all avenues of investigations that are suggested and reasonable.

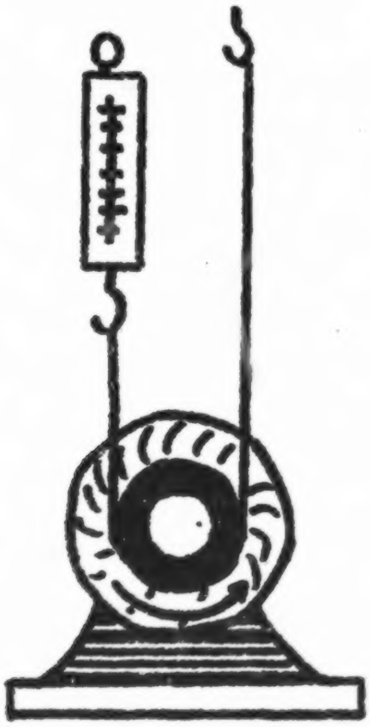
Pass out A-13.

STUDENT A - 13

HORSEPOWER TODAY

We have advanced from the period of using horses to jet engines and rockets. The term horsepower remains the same, however, and science has found no need to change it. Of course, the methods of testing horsepower varies. For example, would you test for horsepower of a jet engine the same way you would test for horsepower of an electric motor? No sir, you would not! How would you test for horsepower of a man? Mr. Watt did this and found an average man to be about one tenth (1/10) of a horsepower.

The electric motor has a wheel on the end. One way to test for the horsepower is as indicated in the drawing.

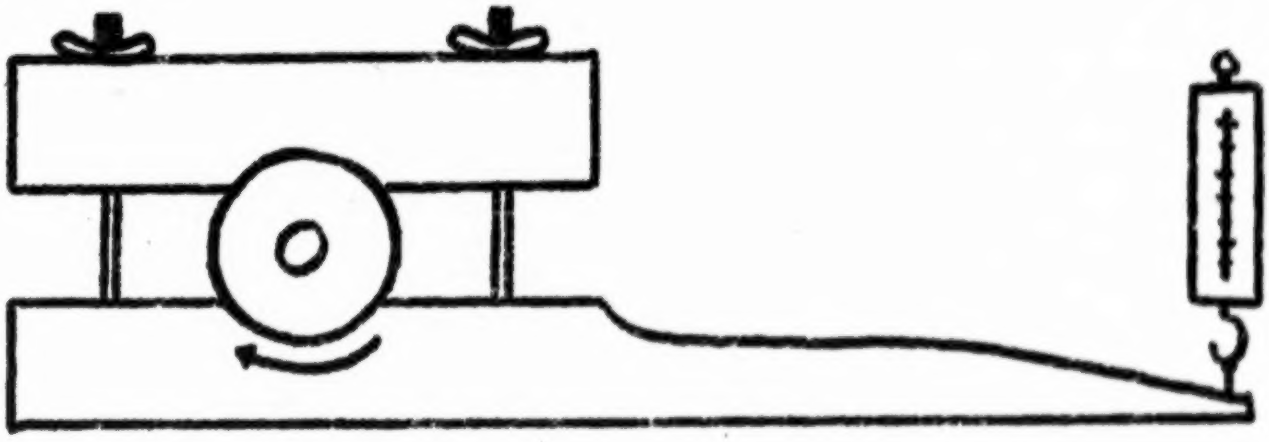


Try to figure out how you could determine the horsepower of the motor in the diagram above. The facts to remember are:

1. The effort force is measured in pounds with a spring balance.
2. The distance traveled will have to be determined from the wheel on the motor by measuring the distance around of the wheel.
3. Time is the number of seconds needed for the wheel to make one complete revolution.
4. One horsepower equals 550 foot-pounds per second.
5. The formula for determining horsepower is:

$$\text{Horsepower} = \frac{\text{Force times distance}}{\text{Seconds times 550}}$$

Another way to determine the horsepower of an engine is to use a "Phony brake." Look at the drawing below and see if you can figure out how it works.



A jet engine is something else. It does not have a wheel that turns, but a strong thrust from the rear of the engine. Could you measure this thrust by placing a set of scales similar to the bathroom scales behind the jet engine to determine the force? Yes sir, you sure could! The distance and time the jet would move would give you all the information needed to determine the horsepower of the jet.

Some of the ways of determining horsepower are listed above on the previous pages. If you will ask your instructor to show you the steam engine, you may be able to determine its horsepower. If you have an electric motor at home or could borrow one, you could also calculate its horsepower.

It seems odd that even in our age of atomic reactors and supersonic jets, the power of a Clydesdale horse is still one of the most important measurements of science.

UNIT 3 THE PULLEY

TEACHER RESOURCE

The apparatus to be used in this unit will be found in Harcourt, Brace, and World; "Classroom Laboratory 6", Blue Drawer. Note that a single fixed pulley is to be mounted in the lower right corner of the hardboard. This pulley will be used for ease of measurement. The spring balance must be supported in an upright position for all measurements. Otherwise, the weight of the spring balance will be included in the reading.

The term "single fixed pulley" refers to the case where only one pulley rotates about a shaft which is fixed or anchored in place, that is, the shaft is not free to move. Using more than one single fixed pulley only changes the direction the effort force must be exerted. The term "single mov~~e~~able pulley" refers to the case where the shaft is free to move in some direction without reference to rotation. The use of more than one single mov~~e~~able pulley will not be investigated.

The pulley will be investigated with reference to mechanical advantage. The mechanical advantage of a single fixed pulley is 1. There will be no gain in force or speed. The product of mechanical advantage and effort force will be the weight of the load, or resistance force. One times any number gives the number. Therefore, in the case of the single fixed pulley, the resistance force will equal the effort force.

The mechanical advantage of the single mov~~e~~able pulley is 2. This can be determined by the formula

$$\text{M. A.} = \frac{\text{Resistance force, or load}}{\text{Effort force}}$$

OR

$$\text{M. A.} = \frac{\text{Distance effort force moves}}{\text{Distance resistance (load) moves}}$$

Mechanical advantage can also be determined by counting the number of supporting ropes. If the effort force is being exerted in the direction that the load moves, it should be counted as a supporting rope. If it moves in the opposite direction then it should not be counted. Refer to the diagram on page 11.

Topic 1 - The single fixed pulley has a mechanical advantage of 1 and changes direction only. The single mov~~e~~able pulley has a mechanical advantage of 2 and does not change direction.

The initial discussion of pulleys should introduce and define the pulley. The students probably have seen many pulleys before in the form of a block and tackle on boats or as a single pulley on a flag pole. Considerable time for assembly of apparatus and completion of the activity will be required for the students have not used the apparatus before. Use your judgement in determining whether the actual experimentation should proceed on the same day as the initial discussion. Use an assembled model along with a prepared acetate as a demonstration.

HOW MANY OF YOU HAVE EVER SEEN ROOFERS SPREADING TAR ON A ROOF? (Discussion) HOW DID THEY GET THE TAR FROM THE GROUND TO THE TOP OF THE ROOF? (The pulley will probably be mentioned. If not, ask about getting water out of a well, or how a crane operates.) YOU HAVE SAID THAT A PULLEY IS USED IN LIFTING SOMETHING. LET'S DRAW A PULLEY. Instruct the students to draw a simple pulley on a piece of paper. Perhaps some student can prepare an acetate for you, or show the acetate or draw a picture of a pulley on the overhead projector. Pointing at the wheel on the drawing, LET'S CALL THIS A WHEEL. Then pointing at the axle, LET'S CALL THIS AN AXLE. SO, A PULLEY IS A WHEEL THAT WILL TURN ON AN AXLE. Discussion. This definition will open many areas of discussion; accept all answers that meet the criteria. A pulley does not have to be a laboratory apparatus, but a machine.

This is a good time to stop if time is running short. If time did run out, a review of the pulley and its definition using an assembled model should be presented before continuing.

OUR ROOF DOESN'T NEED REPAIRING AND WE DON'T HAVE A CRANE TO WORK WITH, BUT WE DO HAVE SOME SMALL PULLEYS THAT WE CAN MAKE MODELS WITH TO INVESTIGATE AND FIND OUT HOW THEY WORK. SO, LET'S GO TO WORK.

Pass out the first page of A-14.

TEACHER DIRECTION A - 14

THE SINGLE FIXED PULLEY

Materials for groups of three: (HBW, Science Kit 6, Blue drawer)

1. 1 hardboard
2. 2 slotted hardboard supports
3. 1 plastic tube
4. 2 pulley wheels
5. 2 bolts, 1 1/2 inches long
6. 2 brass spacers
7. 2 nuts
8. 2 wing nuts
9. 1 lead weight
10. 1 cord, 36 inches long
11. 1 spring balance

Instruct the students to set up the apparatus as shown in the diagram on their activity sheet following the directions below the picture. The teacher should circulate among the groups offering assistance where needed or requested. The students are not to begin the actual experimentation until all have assembled their apparatus and the procedure discussed.

After all have assembled their apparatus, pass out the second page of A-14. Place a prepared acetate on the projector.

FIRST, LET'S WEIGH THE LEAD WEIGHT ON THE SPRING BALANCE AS SHOWN IN THE FIRST DIAGRAM. HOW MUCH DOES IT WEIGH? (Pause) RECORD THIS WEIGHT IN THE BLANK BESIDE THE PICTURE.

NOW, LOOP THE STRING OVER THE PULLEY AS SHOWN IN THE SECOND DIAGRAM AND RECORD THE WEIGHT FROM THE SPRING BALANCE. (Pause) YOU WILL HAVE TO STAND UP-SIDE-DOWN TO READ THE SCALE. IS IT MORE OR LESS THAN THE WEIGHT OF THE LEAD WEIGHT? More.

You will need to remind the students that they are to take the readings while gradually pulling on the string. The movement of the lead weight should be a smooth and a constant rate.

NOW, LOOP THE STRING AROUND THE BOTTOM PULLEY AS SHOWN IN THE THIRD DIAGRAM. GRADUALLY LIFT THE SPRING BALANCE AND READ THE WEIGHT WHILE THE LEAD WEIGHT IS MOVING UP. (Pause) NOW, GRADUALLY LOWER THE SPRING BALANCE AND READ THE WEIGHT WHILE THE LEAD WEIGHT IS MOVING DOWN. (Pause) WHAT IS THIS WEIGHT? WHAT DOES THE SCALE READ HALF WAY BETWEEN THE UP AND DOWN WEIGHT? (Pause) RECORD THIS WEIGHT IN THE BLANK BESIDE THE THIRD DIAGRAM. Explain to the students that this procedure is necessary to eliminate the error due to friction. Only the average weight is used.

HOLDING THE BALANCE UP-SIDE-DOWN BY THE HOOK, READ THE SCALE. HOW MUCH DOES THE SPRING BALANCE WEIGH? (Pause) RECORD THIS WEIGHT BESIDE THE FOURTH DIAGRAM.

The students should keep the apparatus in front of them while discussing the results. HOW MUCH DOES THE LEAD WEIGHT WEIGH? (Discussion) HOW MUCH IS ITS AVERAGE WEIGHT IN THE THIRD CASE AS SHOWN IN THE THIRD DIAGRAM? (Discussion) IT WEIGHS ABOUT THE SAME, DOESN'T IT? THE PULLEY DOESN'T HELP US MUCH THEN, ACCORDING TO THIS DATA. (Discussion) HOW MUCH DOES THE LEAD WEIGHT WEIGH IN THE SECOND CASE WHERE YOU HAD TO READ THE BALANCE UP-SIDE-DOWN? (Discussion) HOW MUCH DOES THE SPRING BALANCE WEIGH? Pause. Weight recorded in the last diagram. IF YOU SUBTRACT THE WEIGHT OF THE SPRING BALANCE FROM THE WEIGHT YOU RECORDED IN THE SECOND DIAGRAM WHEN YOU LOOPED THE STRING OVER ONLY ONE PULLEY, HOW MUCH DID IT WEIGH? (Discussion). HOW DOES THIS COMPARE WITH THE WEIGHT OF THE LEAD WEIGHT? (Discussion). HOW DOES THIS COMPARE WITH THE WEIGHT YOU RECORDED WHEN YOU USED BOTH PULLEYS? (Discussion) THE WEIGHTS ARE ABOUT THE SAME. THE DIFFERENCE IS SO SMALL THAT WE CAN BLAME IT ON FRICTION. (Discussion).

Teacher direction A-14 (continued)

SO WE SEE THAT A FIXED PULLEY ONLY CHANGES DIRECTION. WE MUST PULL ON THE ROPE IN ANOTHER DIRECTION THAN THE RESISTANCE MOVES. HOW DO WE USE THIS MACHINE TO HELP US DO WORK? (Discussion). The teacher should emphasize the point that the single fixed pulley only changes direction and does not gain speed or force.

Instruct the students to disassemble the apparatus and return it to its proper place.

TEACHER DIRECTION A - 15

MOVABLE PULLEYS

Materials for groups of three:

1. 1 hardboard
2. 2 slotted hardboard supports
3. 1 plastic tube
4. 1 pulley block
5. 2 pulley wheels
6. 3 bolts, 1 1/2 inches long
7. 1 hook
8. 3 brass spacers
9. 3 nuts
10. 3 wing nuts
11. 1 lead weight
12. 1 cord, 42 inches long
13. 1 spring balance

A review of A-14 should be presented using an assembled apparatus emphasizing that the fixed pulley only changes the direction the effort force must be exerted. No gain in speed or force is realized. Also point out that the distance the resistance force had to movewas equal to the distance the effort force moved, therefore, no gain in distance.

Pass out the first page of A-15.

Instruct the students to set up the apparatus as shown in the diagram on their activity sheet. This is similar to the previous exercise and should not take long. A quick tour through the room will reveal any difficulties. After all have assembled their apparatus, pass out page 2 of the activity for the actual experimentation. Place the prepared acetate on the projector.

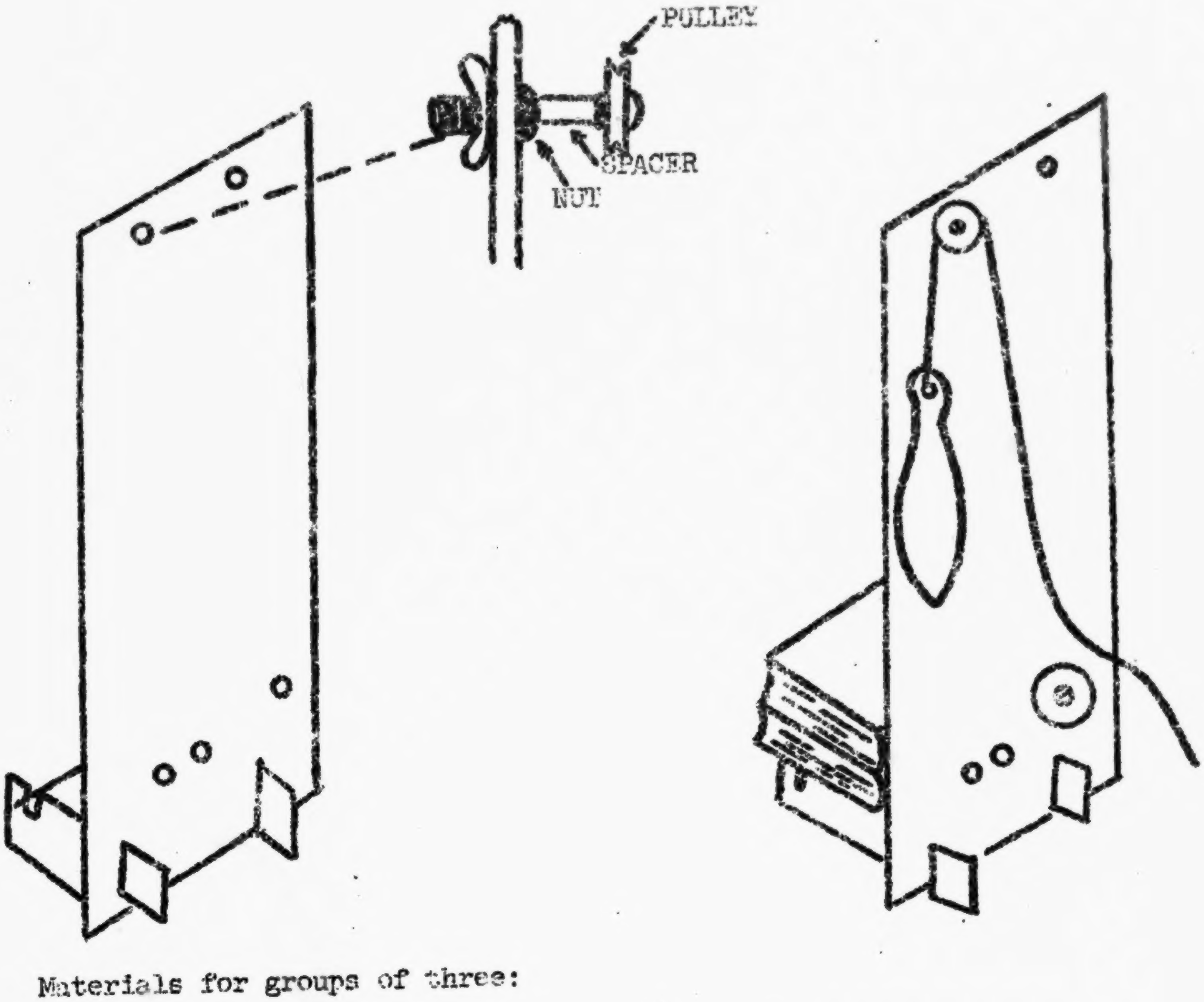
THE FIRST TWO PARTS OF THIS ACTIVITY WILL BE THE SAME AS THEY WERE IN THE LAST ACTIVITY. LOOK AT THE FIRST DIAGRAM ON YOUR PAPER. WHAT IS THE WEIGHT OF THE LEAD WEIGHT? (Pause) IS IT THE SAME AS IT WAS THE LAST TIME? (A-14) RECORD THIS WEIGHT IN THE BLANK BESIDE THE DIAGRAM. (Pause) Record the weight on the acetate.

NOW LOOK AT THE SECOND DIAGRAM WHERE THE STRING IS LOOPED AROUND THE FIXED PULLEYS AT THE TOP AND BOTTOM OF THE HARDBOARD. (Indicate on the acetate) WHAT IS THE WEIGHT OF THE LEAD WEIGHT IN THIS CASE? REMEMBER, YOU HAVE TO MOVE THE WEIGHT UP AND DOWN AND RECORD THE READING IN THE MIDDLE OF THESE TWO READINGS. Pause. IS THE WEIGHT THE SAME AS IT WAS BEFORE? (Pau
Discussion should reinforce the idea that there is no gain in effort.

STUDENT

A - 14

THE SINGLE FIXED PULLEY

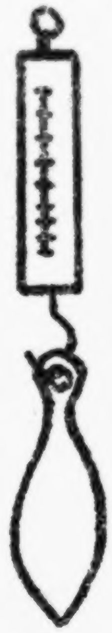


Materials for groups of three:

1. 1 hardboard
2. 2 slotted hardboard supports
3. 1 plastic tube
4. 2 pulley wheels
5. 2 bolts, 1 1/2 inches long
6. 2 brass spacers
7. 2 nuts
8. 2 wing nuts
9. 1 lead weight
10. 1 cord, 36 inches long
11. 1 spring balance

Assemble your apparatus as shown in the diagrams above. The hardboard will need to be placed on the edge of your desk and a couple of books placed on the supports behind the board for added support. The nut next to the spacer should be loose enough so that the pulley wheel will turn freely but not wobble. Follow your instructor's instructions. When everyone has finished, you will receive another sheet of paper to complete the experiment.

NO. 1

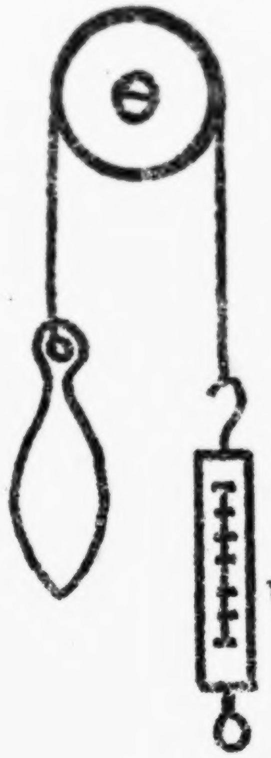


Weight __________
going up

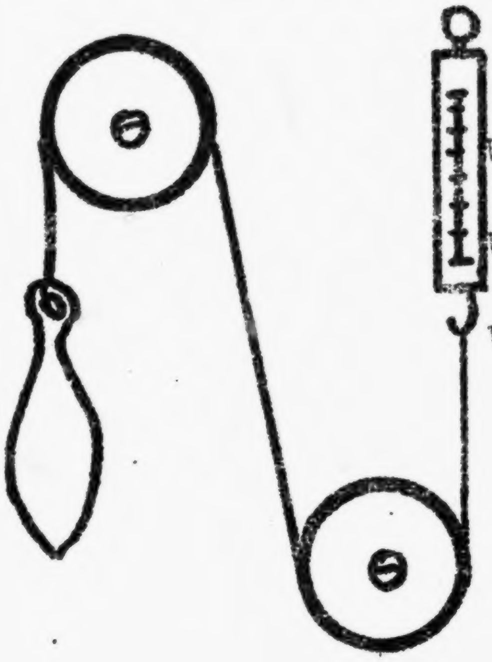
Weight __________
going down

Weight __________
average

NO. 2



Weight ______



Weight ______
going up

Weight ______
going down

Weight ______
average

NO. 3

Weight ________

NO. 4

Teacher direction | A-15 (continued)

LOOK AT THE THIRD DIAGRAM. NOTICE THAT ONE END OF THE STRING IS ATTACHED TO THE HOOK AT THE TOP, LOOPED THROUGH THE MOVABLE PULLEY, AND THEN SUPPORTED BY THE SPRING BALANCE. THE LEAD WEIGHT IS ATTACHED TO THE MOVABLE PULLEY. SET UP YOUR APPARATUS LIKE THIS, AND READ THE SPRING BALANCE. (Pause) WHAT IS THE SPRING BALANCE READING NOW? RECORD THIS READING IN THE BLANK BESIDE THE DIAGRAM. (Pause) HOW DOES THIS WEIGHT COMPARE TO THE WEIGHT OF THE LEAD WEIGHT IN THE FIRST DIAGRAM? (Discussion) THE LEAD WEIGHT, WHICH WE COULD CALL THE RESISTANCE FORCE, IS TWICE THE EFFORT FORCE, ISN'T IT? (Discussion) THE LEAD WEIGHT IS NOW BEING SUPPORTED BY TWO STRINGS RATHER THAN ONE. ANY ADVANTAGE WE GAIN WHEN WE USE A MACHINE TO MAKE OUR WORK EASIER IS GIVEN A SPECIAL NAME, MECHANICAL ADVANTAGE. THE MECHANICAL ADVANTAGE OF THE PULLEYS IN THE THIRD DIAGRAM IS 2. THIS MEANS THAT WE CAN LIFT TWICE AS MUCH WEIGHT WITH THE MACHINE AS WE COULD WITHOUT THE MACHINE. WE CAN ALSO TELL THE MECHANICAL ADVANTAGE BY COUNTING THE NUMBER OF STRINGS WHICH SUPPORT THE RESISTANCE. (Pause for discussion and explanation.) This is a new concept and may not be readily understood.

THE MECHANICAL ADVANTAGE OF THE PULLEYS IN THE SECOND DIAGRAM WHERE YOU HAD ONLY FIXED PULLEYS WAS 1. CAN YOU TELL WHY? (Discussion) THE MECHANICAL ADVANTAGE OF ANY FIXED PULLEY WILL BE 1. (Discussion)

LET'S LOOK AT THE FOURTH DIAGRAM. HERE THE STRING IS ATTACHED TO THE HOOK, LOOPED THROUGH THE MOVABLE PULLEY, OVER THE FIXED PULLEY AT THE TOP, AND UNDER THE FIXED PULLEY AT THE BOTTOM. SET UP YOUR APPARATUS LIKE IT IS AND RECORD THE READING FROM THE SPRING BALANCE. REMEMBER, YOU MUST MOVE THE WEIGHT UP AND DOWN, AND RECORD THE AVERAGE OF THE READINGS. (Pause for experimentation and assistance.) WHAT MECHANICAL ADVANTAGE DID YOU RECORD? (Pause) HOW DO YOU KNOW? (Discussion)

Time will probably run out. If some time is left, let the students experiment on their own. Instruct them to disassemble their apparatus and return it at the end of the period.

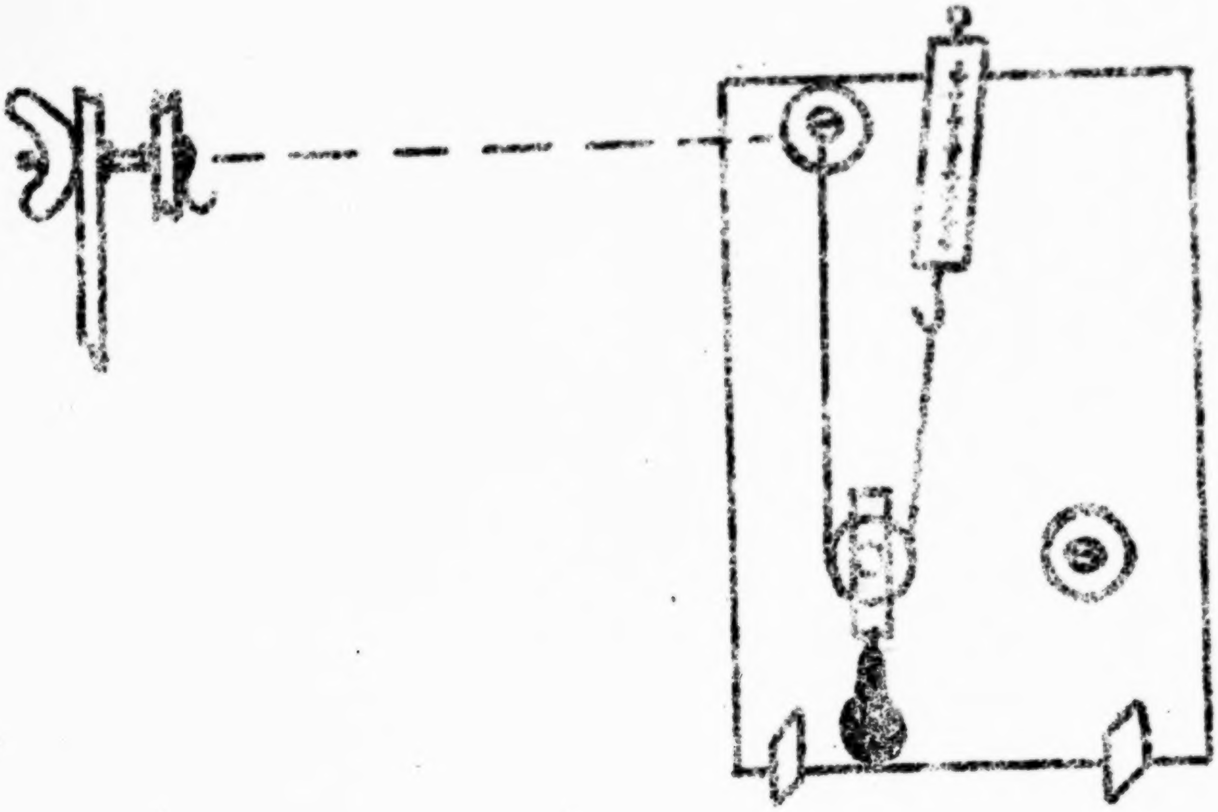
STUDENT

A - 15

MOVABLE PULLEYS

Materials for groups of three:

1. 1 hardboard
2. 2 slotted hardboard supports
3. 1 plastic tube
4. 1 pulley block
5. 2 pulley wheels
6. 3 bolts, 1 1/2 inches long
7. 1 book
8. 3 brass spacers
9. 3 nuts
10. 3 wing nuts
11. 1 lead weight
12. 1 cord, 42 inches long
13. 1 spring balance



Set up your apparatus the same as you did in the last activity. Refer to the diagram above. After completion, your instructor will give you the second page of the activity for experimentation.

Topic 2 - Combinations of movable pulleys have mechanical advantages of
2 or more.

TEACHER DIRECTION

A - 16

COMBINATIONS OF PULLEYS

Materials for groups of three:

1. 1 hardboard
2. 2 slotted hardboard supports
3. 1 plastic tube
4. 1 pulley block
5. 3 pulley wheels
6. 2 bolts, 1 1/2 inches long
7. 2 brass spacers
8. 2 nuts
9. 2 wing nuts
10. 1 lead weight
11. 1 cord, 48 inches long
12. 1 spring balance

A short review of A-15 using the overhead projector should be used to introduce this activity. Emphasize the concept of mechanical advantage.

Instruct the students to assemble their apparatus as indicated in the first page of their activity sheet. Note the addition of the second fixed pulley at the top. After they have assembled their apparatus, have them proceed on their own to determine the mechanical advantage of the machine. Circulate among the groups offering assistance where needed. Allow sufficient time to complete the experiment and also suggest that they devise experiments of their own. Collect the materials near the end of the period leaving only a short time for discussion.

The final discussion should take the form of a question and answer session allowing the students to tell about the experiments they did on their own.

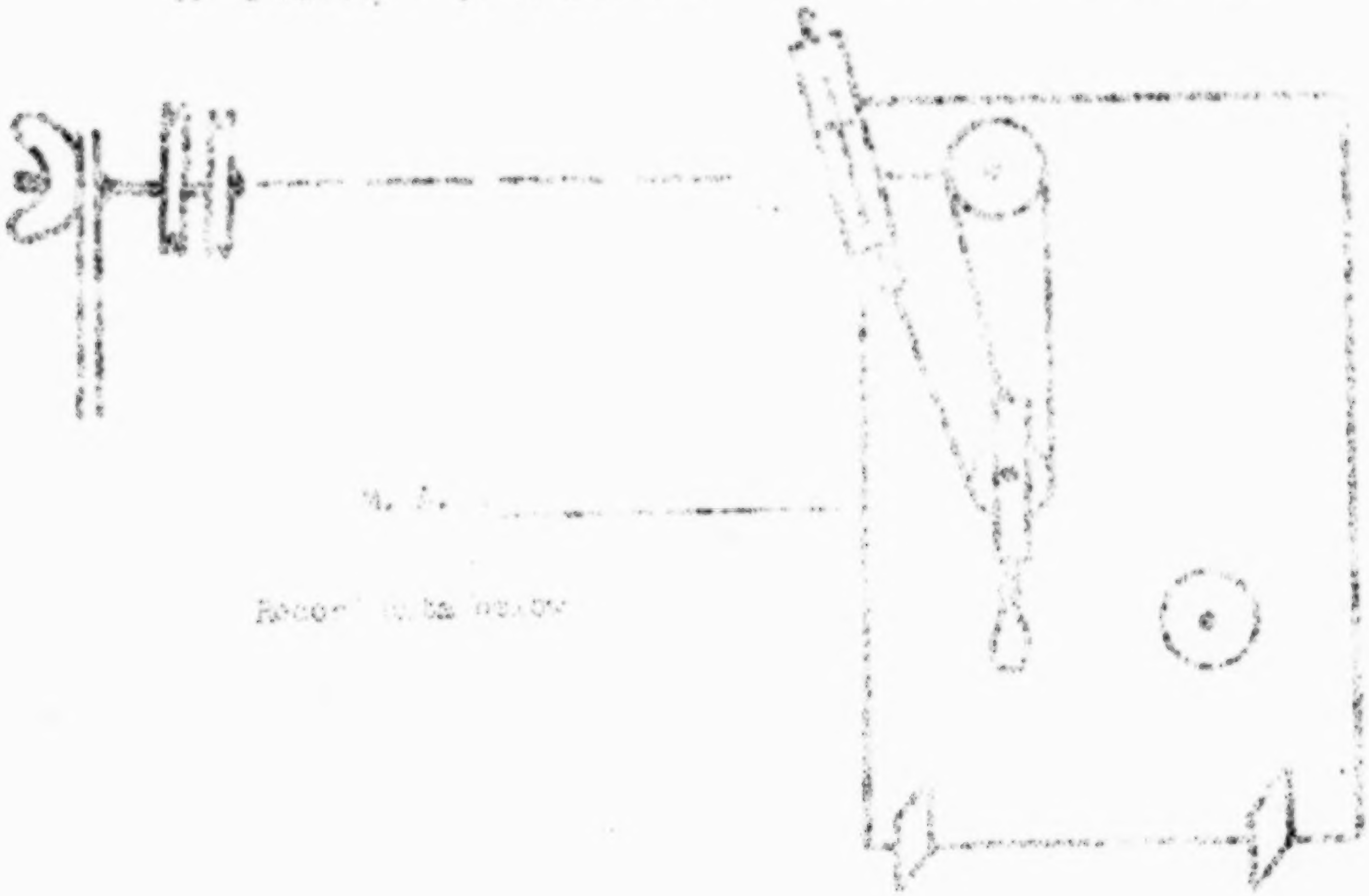
The next unit is on friction. The need to investigate the nature of friction, ways to reduce it, and friction as a source of experimental error should be mentioned.

STUDENT [illegible]

[illegible]

Materials for groups of [illegible]

1. 1 [illegible]
2. 2 slotted hardboard support.
3. 1 plastic tube
4. 1 pulley wheel
5. 3 roller wheels
6. 2 bolts, 1 1/2 inches long
7. 2 brass [illegible]
8. 2 nuts
9. 2 wing nuts
10. 1 lead weight
11. 1 cord, 30 inches long
12. 1 spring balance

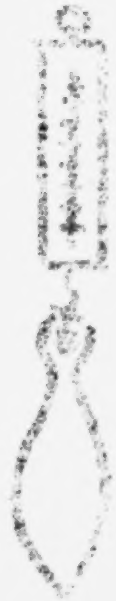


M. A. ______________

Record data below

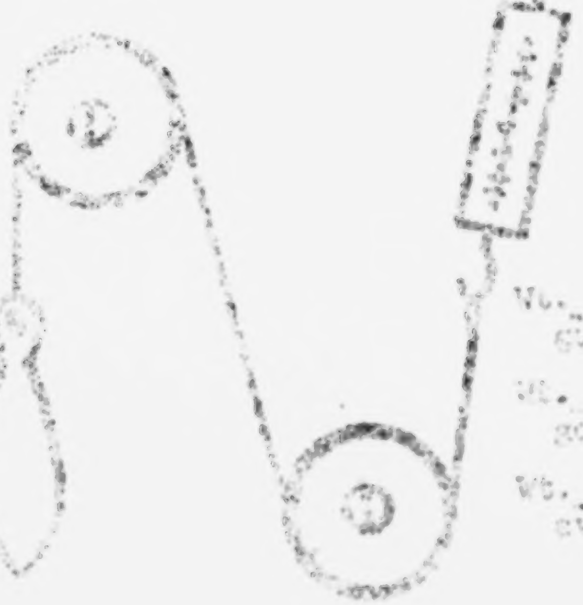
Set up your apparatus like the diagram above. Determine the mechanical advantage. In like manner, set up other combinations and determine their mechanical advantage. You should be able to determine it two different ways. Can you?

NO. 1



Weight______

NO. 2

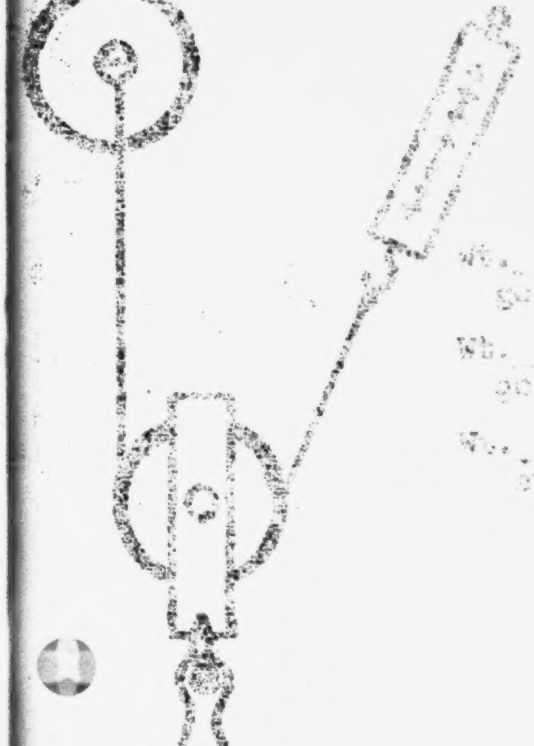


Wt.______ going up

Wt.______ going down

Wt.______ average

NO. 3

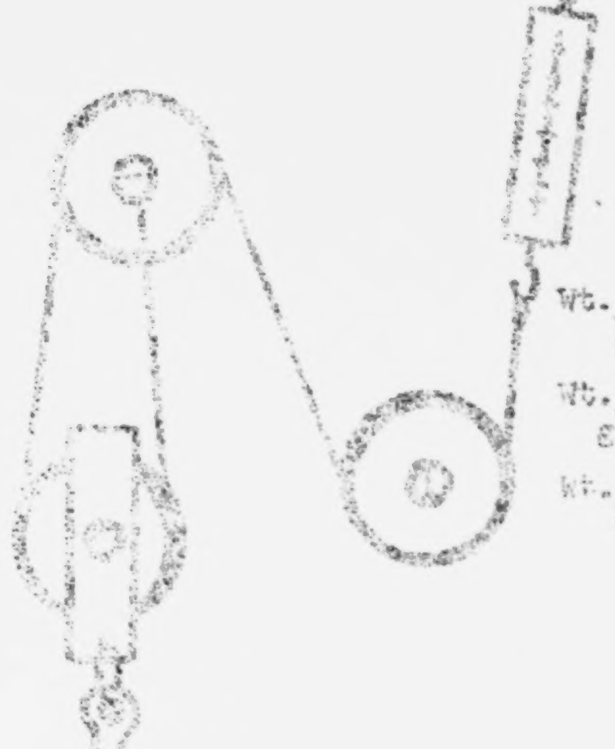


Wt.______ going up

Wt.______ going down

Wt.______ average

NO. 4



Wt.______ going up

Wt.______ going down

Wt.______ average

UNIT [illegible]

FRICTION

TEACHER REFERENCE

The resistance of friction may be defined as the force that opposes the motion of one object's surface sliding over another or of one object moving through another. This may be the result of attraction of the surfaces or the irregularities of the surfaces, or both. The direction of the friction force is opposite the effort force, but it is in the same direction of the resistance force which opposes the effort force. The force of friction is dependent on the following conditions:

1. The resistance force of friction is directly proportional to the weight. If it takes 1 pound of force to pull a brick, it would take two pounds of force to pull two bricks.
2. The force of friction depends on the types of surfaces involved.
3. Other things being equal, the force of friction does not depend on the amount of surface area. Whether a brick slides on the narrow side or flat side does not matter unless it digs into the surface.
4. Starting friction is greater than sliding friction. When an object sets, it settles and the surfaces come closer together increasing the attraction for each other as well as more interlocking of irregularities.
5. Heat is produced by friction.
6. Lubricants reduce friction, and so lessen the effort force required to overcome friction.
7. Substituting rolling parts for sliding parts reduces friction.

Topic 1 - The force of friction is directly proportional to the weight and with other things being equal, it does not depend on area.

Most of the students will have an understanding of friction. The teacher can capitalize on this factor in the discussions. The terms movement and motion should be used interchangeably by the teacher to introduce the term motion.

IN MANY OF THE ACTIVITIES YOU HAVE SAID THAT FRICTION SHOULD BE CONSIDERED SINCE IT CAUSED AN EXPERIMENTAL ERROR. I AGREE WITH YOU. LET'S CONSIDER FRICTION AND REALLY TRY TO FIND OUT HOW IT WORKS. WHAT IS FRICTION? (Discussion)

Use the overhead projector and write all the answers on the acetate. Approach friction as a resistance force that opposes the effort force. Ask the students if friction decreases the effort force or increases the resistance force each time they suggest an answer to the question, what is friction?

LET'S DEFINE FRICTION AS A FORCE THAT CHANGES MOVEMENT. THIS IS WHAT WE HAVE REALLY BEEN SAYING, ISN'T IT? (Discussion) LET'S CONSIDER THE AREA OF AN OBJECT LIKE A PIECE OF WOOD. WHICH SIDE WOULD HAVE THE MOST FRICTION, THE WIDE SIDE OR THE NARROW SIDE? (Use a block of wood to demonstrate.) HOW COULD YOU TEST AND FIND OUT IF THE AREA MAKES ANY DIFFERENCE? (Discussion t plan A - 17)

Do not tell the students the answer. Ask how and why freely. Also support the idea that friction opposes the effort force.

Pass out sheet A - 17.

TEACHER DIRECTION A - 17

SURFACE AREA AND FRICTION

Each group is to pull a block of wood along a flat surface by means of a spring balance connected to the block with a rubber band. The teacher should demonstrate the procedure and stress the importance of exerting the force slowly and steadily to obtain accurate results. The force required to initiate movement will be greater than the force needed to maintain a constant speed.

Students are to take turns as an observer to read the balance. Each student will record the observers' findings.

After the students complete the activity, return to a class situation to interpret the data. Using a prepared acetate, discuss the findings. The important point to stress is that surface area is not important, but rather something else. Do not tell the students what the significant factors are because they will discover them in the next activity.

WHAT IS THE WEIGHT OF THE BLOCK OF WOOD? All blocks should weigh approximately the same. Write the weight suggested by the students under both drawings of the block. LET'S CONSIDER THE BLOCK WHEN IT WAS LYING ON ITS BROAD SIDE. WHAT WAS THE FORCE REQUIRED TO START THE BLOCK MOVING? (Record the answers on the acetate.) WHAT WAS THE FORCE REQUIRED TO MAINTAIN A STEADY SPEED? (Discussion)

NOW, LET'S CONSIDER THE BLOCK WHEN IT IS LYING ON ITS NARROW SIDE. WHAT IS THE FORCE REQUIRED TO START THE BLOCK MOVING? Stress the relation of surface area between the two drawings on the acetate and record the finding as before. Some acting will be necessary. WHAT IS THE FORCE REQUIRED TO MAINTAIN A CONSTANT SPEED? Stress the relationship of the forces and the surface area. WHAT DO THESE RESULTS SHOW? The force of friction does not depend on the surface area. The starting friction is greater than sliding friction.

IF YOU INCREASED THE WEIGHT OF THE OBJECT TO BE MOVED, WOULD THE FRICTION INCREASE? Yes. (Discussion) A factor that must be considered in testing is to maintain the same surfaces and vary the weight. Develop the procedure for A-18 in this discussion.

TEACHER DIRECTION A - 18

WEIGHT AND FRICTION

Materials for groups of three:

1. 1 rubber band
2. 1 spring balance
3. 2 wood blocks

STUDENT A - 17

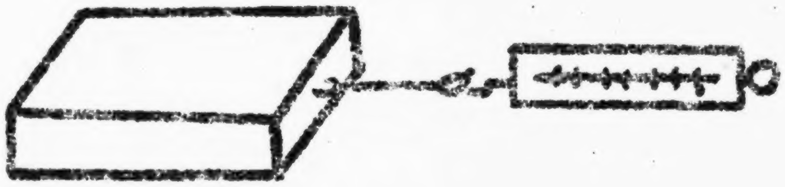
SURFACE AREA AND FRICTION

Materials for groups of three:

1. 1 rubber band
2. 1 spring balance
3. 1 piece of wood

Scientists have many ideas about friction, and their observations have been quite different from what most people expected. The activity that follows will show something that seems rather strange at first, but we must accept the experimental data.

Attach one end of the rubber band to the nail on the block of wood and the other end of the rubber band to the spring balance as shown in the diagram below.



The block is to be moved by pulling very slowly on the spring balance until it starts to move. One student is to pull the spring balance. One student is to read the balance. One student is to record the data. Record all observations in the table on the next page. All students must complete the table.

Data on Friction

Observer number	Force required to start the block moving	Force required to maintain a constant speed	Position of Block	Weight of Block
1			Wide side	
			Narrow side	
2			Wide side	
			Narrow side	
3			Wide side	
			Narrow side	

It was believed for a long time that the force of friction depended on the surface area. Do your results support this statement that the surface area is important?

Teacher direction   A - 18 (continued)

The procedure for A-18 is identical to the procedure used in A-17. The only changes are variations in weight. Let the students pursue the activity without detailed explanations. Encourage the students to read the directions very closely.

After the completion of the activity, discuss the results. Use the same prepared acetate as used in A-17. Draw a second block over the single block drawn on the acetate in a different color, then record the data obtained on the acetate. Solicit results from the class following the same procedure used in A-17. Stress that weight is a factor in friction, not surface area.

The students are to make drawings. Stress thought rather than artistic ability. The teacher should assure student understanding before the students begin drawing. Assure this understanding in small group discussion, not by class discussion. Compliment the students whenever possible. It is suggeste the prepared acetate used in A-17 be placed on the overhead projector to be used as reference if needed.

After the students complete the drawings, instruct them to disassemble their apparatus and return for a class discussion. If some of the students show an interest in drawing, have them prepare an acetate to demonstrate before the class.

The discussion to this point has only considered the friction involved in hard flat surfaces. It should be recalled at this point that weight is significant, but surface area is not an important factor when hard flat surfaces are used.

Topic 2 - The force of friction depends on the type of surfaces involved.

The following activities are to investigate forces of friction on surfaces that are not smooth. The students will probably already know the factors involved when surfaces are not smooth or hard, but they can make a quantitative investigation. Encourage individual investigations and permit all reasonable requests to investigate suggested possibilities.

WE HAVE SHOWN THAT THE SURFACE AREA IS NOT IMPORTANT WHEN OBJECTS WITH HARD FLAT SURFACES ARE MOVED OVER OTHER HARD FLAT SURFACES. THE IMPORTANT FACTOR IS THE WEIGHT. LET'S NOW CONSIDER A CONDITION WHEN THE SURFACE IS NOT HARD OR SMOOTH. PLACE ONE HAND ON TOP OF THE OTHER HAND SO THAT THE PALMS ARE TOGETHER. (Demonstrate) NOW, WITHOUT EXERTING PRESSURE, START MOVING YOUR HANDS BACK AND FORTH OVER EACH OTHER. NOW, GRADUALLY EXERT MORE PRESSURE UNTIL YOU CANNOT MOVE YOUR HANDS AT ALL. WHAT IS THE IMPORTANT FACTOR, WEIGHT OR SURFACE AREA? (Both are important.) Accept all answers and list the remarks on the overhead projector. Since the surface area remained the same, weight again is a significant factor.

Teacher Direction A - 18 (continued)

NOW, INTERLOCK YOUR FINGERS WHILE HOLDING YOUR HANDS STRAIGHT. HOLD YOUR HANDS CHIN HIGH AND TRY TO PULL THEM APART. CAN YOU PULL YOUR FINGERS APART IF YOU EXERT ALL THE PRESSURE YOU CAN? NOW INTERLOCK YOUR FINGERS WITH YOUR NEIGHBOR'S FINGERS AND SEE WHICH ONE OF YOU CAN PREVENT THE OTHER FROM PULLING HIS HAND AWAY. Instruct the students to remain in their seats. Otherwise it may become unmanageable. SCIENTISTS SAY, A WEIGHT FORCES TWO OBJECTS CLOSER TOGETHER AND INTERLOCKING RESULTS. THEREFORE, THE FRICTION INCREASES. DO YOU AGREE WITH THIS STATEMENT? (Discussion) Accept all answers. Lubricants will probably be mentioned, but a lubricant prevents objects from coming in contact with each other. The degree of attraction of the surfaces under consideration is another important factor that may arise. An example of attraction is glue; it may stick on some objects and not stick on others.

LET'S INVESTIGATE SEVERAL DIFFERENT KINDS OF SUBSTANCES TO DETERMINE THE FORCE OF FRICTION AND THEN COMPARE THE RESULTS.

Pass out sheet A - 19.

TEACHER DIRECTION A - 19

THE FORCE OF FRICTION DEPENDS ON THE TYPE OF SURFACE

Materials for groups of three: (HBW - Science Kit 6, Investigation 21, blue drawer)

1. Spring balance
2. Blue friction board
3. Yellow friction board
4. Truck
5. Rubber band
6. Lead weight

The students are to proceed on their own. Instruct them to follow the directions and record all results in the tables.

After completing the activity reassemble for a class discussion. Using the prepared acetate, discuss the findings. Complete the table before answering the questions at the end of the activity. If students have questions concerning the activity, explain that the table must be completed first in order to obtain the necessary data to draw conclusions. During discussion of the table stress the point that the forces of friction in rolling friction are less than in sliding friction. When sliding friction alternately sticks and slips, it may be called stick-slip friction. Stick-slip friction is (generally) greater than other sliding friction because of the rough surfaces.

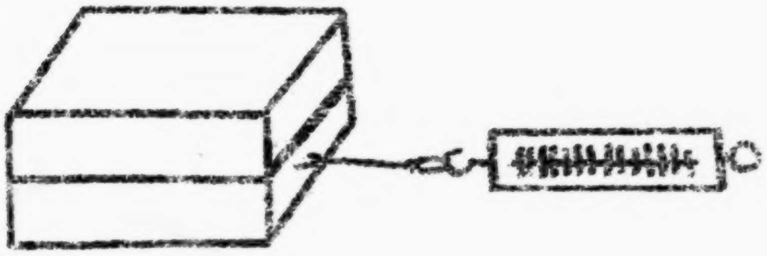
After completing the tables, discuss the questions using free hand drawings on an acetate to illustrate answers. Ask the students to help formulate statements to be used in writing an outline of the conclusions on this acetate along with the drawings.

STUDENT A - 18

WEIGHT AND FRICTION

Materials for groups of three:

1. 1 rubber band
2. 1 spring balance
3. 2 pieces of wood



How does weight effect friction on a hard flat surface? If by increasing the weight, the force of friction changes, then you could prove that weight is an important factor effecting friction.

The procedure for this activity is the same as A - 17. Remember you are to work as a group. One student is to pull the spring balance. One student is to read the balance. One student is to record the data. Complete the table below.

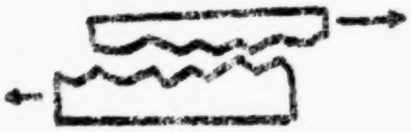
Data on the Effect of Increased Weight on Friction

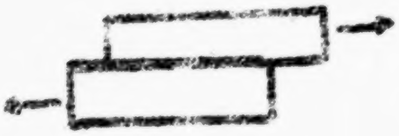
Observer Number	Position of Block	Number of Blocks	Force required to start the block moving	Force required to maintain a constant speed
1	Wide side	1		
	Wide side	2		
2	Narrow side	1		
	Narrow side	2		
3	Wide side	2		
	Narrow side	2		

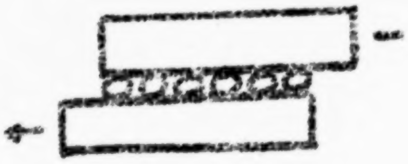
Make a drawing of the apparatus and label the parts. Write on the drawings the effort force observed above the spring balance. This will require four drawings. Your drawings should show a point, so first determine what you are showing, then arrange your drawings to best show your point.

Teacher direction A - 19 (continued)

Below are examples of drawings to be sketched at the most opportune time:







Having made the point that friction between hard surfaces does not depend on the surface area, raise questions regarding the use of large wheels or a caterpillar tread on farm tractors or on road building machinery. These tractors pull harder on loose earth than would be the case if the surface area between the wheels and the earth were less. If questions arise that can be demonstrated, allow the students to demonstrate the point in question.

After completing the questions, play the "Would you believe" game.

WOULD YOU BELIEVE, A WHEEL ON AN AUTOMOBILE HAS BOTH ROLLING FRICTION AND SLIDING FRICTION? Yes. It has rolling friction in the ball bearings as well as rolling on the highway. Sliding friction is what makes the automobile move.

WOULD YOU BELIEVE THAT A SQUEAKY DOOR IS AN EXAMPLE OF SLIP-STICK FRICTION? Yes. The noise is due to an alternate sticking and slipping, sometimes called stick-slip friction. Lubrication makes the friction a continuous sliding friction by introducing other substances that slide more easily.

WOULD YOU BELIEVE, THAT OIL ON A SQUEAKY DOOR WORKS BECAUSE THE OIL PROVIDES NEW SURFACES AND THAT THE NEW SURFACES HAVE LESS FRICTION THAN THE DRY HINGES ON THE SQUEAKY DOOR? Yes. The lubricated surfaces have less attraction. The lubrication could be an oil or graphite, both serve the same purpose.

Topic 3 - Heat is produced by friction. Lubricants reduce friction, heat, and the effort force.

The relation of friction and heat can best be explained technically by the molecular theory, but the abstraction of atoms and molecules prevents the introduction of molecular explanations. The initial approach to this topic is to provide an introduction to the unit on heat. To measure heat due to friction alone is difficult and complicated. Therefore, the activities must be limited.

A - 19

STUDENT

TYPE OF SURFACE AND FRICTION

Materials for groups of three:

1. Spring balance
2. Blue friction board
3. Yellow friction board
4. Truck
5. Rubber band
6. 4 ounce weight

Friction is a force that opposes the effort force. This makes friction a very important factor when trying to move objects from one place to another. Scientists classify friction in many different ways. Some of the important classifications are: sliding friction where one object is pulled over another object, rolling friction where wheels or something round is used, and stick-slip friction where an object seems to stick, then jerk forward. In this activity, you will find examples of all three of these. See if you can classify them.

The procedure for this activity is the same as used in A - 18. One student is to pull the object to be tested. One student is to record the data. One student is to be the observer and read the balance accurately.

Record all data in the tables.

If the balance will not measure the force, write "cannot tell".

Testing is to be performed on a flat table top that is smooth.

Friction on a Smooth Surface

Object	Position	Force required to maintain a constant speed	Type of friction
Truck	Rolling		
	Side		
	Rolling + weight		
Yellow friction board	Smooth side down		
	Rough side down		
	Rough side of yellow board on the Rough side of blue board		

Friction in Loose Sand

Testing is to be performed outside in the sand.

Object	Position	Force required to maintain a constant speed	Type of friction
Truck	Rolling		
	Side		
	Rolling + weight		
Yellow friction board	Smooth side down		
	Rough side down		
	Rough side of yellow board on the rough side of blue board		

A - 19

Many conclusions can be drawn from the findings you have recorded. By using your results answer the following questions.

1. Is friction greater in sand or on a table top? How do you know?

2. When is friction the greatest, in sliding friction, in rolling friction, or in stick-slip friction? How do you know?

When the rough surface of the yellow friction board is placed on the rough surface of the blue friction board, the resistance force of friction was very high. This high resistance force of friction is due to two things: the surface of the rubber foam, and the attraction of the foam to stick together. List three examples where rubber or similar material can be used to advantage. (An example would be a rubber shoe sole replacing leather to prevent slipping.)

1.

2.

3.

Sand is generally little round pebbles that are very hard. When you pull something very flat over the sand, it slides very easily. The sand in this case would be either sliding friction or rolling friction. Explain how it could be both sliding friction and rolling friction.

1.

2.

STUDENT A - 20

HEAT AND FRICTION

Have you ever watched a poor driver try to start very fast or "spin-off" in sand? What happens? Well, a whole lot happens, but one thing that does happen is that the automobile does not go anywhere but down--down in the sand. The unhappy driver then gets out of the car for a scientific investigation to correct his errors. If we were this unhappy driver, what could we find out? Let's try to imagine the conditions and analyze the data that can be obtained.

The first and most obvious thing is that the rear wheels were spinning. The friction between the tires and the sand was not great enough to move the car forward. One explanation could be that the sand grains are round and therefore have rolling friction like the wheels. If we recall our experiments, we would remember that the more weight you have, the greater the friction. Conclusion number one would be, if the car is to get out it needs more weight over the driving wheels. But by this time the tires are deeper in the sand.

The next thing to notice would be the tires. Would the treads have enough traction? Do rough treads have more traction than smooth treads? The treads cannot be altered, but what about the surface area? Would it increase the friction if we let some air out of the tires? It would give a broader surface and the tires would not sink into the sand as fast as when it is full of air. Conclusion number two would be, let some air out, but not enough to give you a flat tire.

The tires have also dug a hole into the sand. The hole is the same as an inclined plane and it takes more effort force to climb an inclined plane than to move along a level surface. So, the third conclusion is, dig some sand out from in front of the tires.

The tires were smoking when you first got out of the car and you feel of one of them to see if it is hot. It is hot! Why did the tire get hot? It must be due to the friction of the tires spinning in the sand. Obviously you should wait until the tires cool. As you sit down to wait you begin to think about friction and heat. It's not really unusual that the tires got hot. If you rub anything together it becomes hotter. Even by just rubbing your hands together they get hotter. If you rub a match against a piece of sandpaper it gets hot enough to burn. If you rub a piece of ice it melts faster. It seems heat is the result of friction.

So, perhaps if friction is reduced, heat will be reduced. Industry uses this idea of heat and friction in all their machines.

The first real scientific knowledge was given to the world in early 1800 by an American, Benjamin Thompson. He noticed that as holes were being bored into brass to make cannons, then the metal became so hot, if a person touched it, a big blister would result. This observation lead to many investigations. Scientists began developing lubricants such as oil, grease, graphite, plastics and many others. They discovered that smooth surfaces reduce friction and that hard "ball shaped" objects, called ball bearings, have the least amount of friction. So the ball bearing was developed and oil was added as a lubricant. Lubricated ball bearings were a most important invention. It is said the wheels of industry turn on lubricated ball bearings.

Scientists continued to investigate lubrication and the findings are not unusual. The lubrication does one thing; it coats the surface of the object and therefore gives another surface that has less friction. Lubricants do not have to be a liquid, but can be a plastic or even a gas. Just the addition of a new surface that has less friction is a lubricant.

Millions of dollars have been spent on lubrication. Heat, however, is not the only reason lubricants are used. Lubricants also prevent objects from wearing out so fast. What actually takes place is that the surface of the object is coated and doesn't touch anything but the lubricant. Friction is needed sometimes like on the brakes of a car. It would be a sad day if someone oiled the brakes on a car. What happens to your brakes when they get wet? It would be another sad day if someone poured oil on the highway. What do you think would happen if someone put grease all over a railroad track?

It seems we have forgotten about the stuck car, so let's dig out in fron of the tires and start off very slowly. It may work, and the car can travel to wherever the driver wishes to go.

Just one question seems unanswered. Why do boys lubricate their hair? Some even use that "greasy kid stuff".

STUDENT A - 21

NEARLY FRICTIONLESS

Materials for groups of three:

1. Dry ice (frozen carbon dioxide)

Everything that moves has some opposing friction. Just movement in the air provides an opposing force against movement, or friction. In this experiment you are to use dry ice. This substance is a solid that doesn't melt, it just evaporates. The gas that is given off provides a lubricant, or in other words, the block of ice produces a gas that floats the solid above the table.

NOTE: DRY ICE WILL 'BURN'. HANDLE THE ICE WITH TONGS ONLY.

Your instructor will show you where to test the ice for friction. Follow his directions for safety.

1. Place the ice in the location assigned. Then barely touch the block of ice with your tongs to see if it will move easily.
2. Blow on the ice and see if you can move it by blowing on it.

Answer the following questions: (Use the back of the sheet if needed)

1. Is the block of dry ice nearly frictionless?_________ How do you know?

2. What is the lubricant?____________________How can you tell?

3. Would a block of regular ice work the same way?____________ Why or why not?

4. If ice melts to water, would the water act as a lubricant or as a glue? ________________________ How could you test it?

5. Why is it so easy to skate on ice?

6. What happens when you touch an ice tray from the freezer with wet hands?

UNIT 5

HEAT

TEACHER RESOURCE

Heat is a term relating to energy. The direction of flow of heat energy is determined by temperature. It should be noted that temperature is not a measure of heat, but a measure of hotness and coldness. The heat will flow from the hot area to the cold area. The temperature is a qualitative measurement indicating the direction of the flow of heat. It is commonly measured in degrees on the Fahrenheit and Centigrade Scales. Technically, temperature can be defined as the state of a body which determines the transfer of heat to or from other bodies. Heat energy always flows from a body AT A HIGHER TEMPERATURE TO A BODY AT A LOWER TEMPERATURE. Whenever heat energy flows from a hotter body into a cooler body, the hotter body becomes cooler and the cooler body becomes hotter. The heat transfer is therefore an energy loss or gain in the internal energies of the bodies. Heat refers to the quantity of energy present while temperature refers to the degree of hotness or coldness. Heat energy is measured in B.T.U.'s (British Thermal Units) or in calories. One B.T.U. is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. One calorie is the amount of heat required to raise the temperature of one gram of water one degree Centigrade. A Kilocalorie (large calorie, food calorie, written with a capital 'C') is the amount of heat required to raise the temperature of one kilogram (1000 grams) of water one degree Centigrade. The relationship of heat and temperature must be made clear to prevent confusion.*

Heat is representative of energy. Temperature is a qualitative measurement of this energy. The following statements can be made concerning heat and temperature:

1. Heat is energy and therefore can perform work.
2. Temperature can be measured by the various scales using the principle of expansion and contraction of the medium being considered.
3. Heat will move from the higher temperature to the lower temperature.
4. The rates of chemical reactions are influenced by temperature.
5. Evaporation is a process of heat exchange and therefore can produce cooling due to the release of heat energy from the internal system undergoing evaporation.
6. The rate of cooling is not a straight line relationship but a curved line. A graph will readily prove this relationship when temperature is plotted in relation to time.
7. Differing materials exhibit differing insulation qualities.
8. The kindling temperature is the temperature at which a substance will take fire and continue to burn. This temperature is critical. Below this temperature no flame will occur. Above this temperature or at this temperature flames will occur.

The activities in this unit are to develop an appreciation of the energy relationships of heat. Heat is a vital factor in everyday life. It is one of the most important factors in our physical and biological environment. The orientation of the entire unit will reflect these relationships.

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*A good reference is Dull, Metcalfe, and Williams, Modern Physics, New York: Holt, Rinehart, and Winston, 1960, pp 217-229.

Topic 1 - Heat is energy and can perform work.

The introduction of the heat relations should follow smoothly and without a recognizable break following friction. The last two activities (A-20, A-21) stressed the relationship of heat, friction, and the use of a gas to reduce friction. The gas, however, was from a very cold piece of dry ice. The heat relation is the important factor that will provide the basis of approach.

The steam engine may be used in this section at any opportune time, if interest is high enough. You may wish to probe deeper into the actions of the engine, but little reference will be made to the steam engine in this material. You may wish to prepare a prepared acetate.

INDUSTRY HAS SPENT MILLIONS OF DOLLARS TO REDUCE FRICTION. IT HAS ALSO SPENT MILLIONS OF DOLLARS TO FIND BETTER WAYS TO USE THE ENERGY OF HEAT. LET'S SEE HOW MANY APPLICATIONS OF HEAT ENERGY WE CAN LIST. Write all suggestions on an acetate.

Interject the term energy at every opportunity and compliment the use of it, but do not require its use. If temperature is used in student discussion, explain it as an indication of hotness and coldness, but do not discuss the relationship of temperature and heat at this point. Use only casual remarks that will interject validity when needed. Along with every suggestion, stress movement of the heat energy from one location to another. An example would be, if someone names a stove, remark the heat energy travels into the food being cooked, or ask the students where the heat is moving.

WE COULD GO ON AND ON AND ON WITH THIS LIST BECAUSE WE USE HEAT SO MUCH. LET'S TAKE A LOOK AT WHAT WE ALREADY KNOW. THE FIRST THING WE SEE IS THAT HEAT MOVES FROM ONE PLACE TO ANOTHER. REGARDLESS OF WHAT CAUSES THE HEAT, IT MOVES, SO LET'S LOOK AT SOMETHING THAT REALLY HAS A LONG HISTORY OF IMPORTANCE TO SCIENCE. (Pick up a drill and bit.) WHAT IS THIS? Discussion if needed, but all the students should be very familiar with the drill. DO YOU BELIEVE THIS WILL PRODUCE HEAT? Accept all answers but do not explain what you are going to do. Ask one student to volunteer to assist you. Then drill a small hole in a block of hard wood. Ask the student to touch the bit carefully so he can feel the heat transfer. WHAT HAPPENED? Discussion. WHERE DID THE HEAT COME FROM? (Friction) WHERE DID THE HEAT ENERGY TRAVEL TO? (The air and the boy's hand) IT SEEMS THAT WE CAN REMOVE THE HEAT. CAN YOU THINK OF ANY WAY WE COULD KEEP THE BIT COLD? The answer you are seeking is to obtain something that will absorb the heat. If you do not get the answer you want, then suggest that water might be used to remove the heat. Ask for a volunteer to fill a beaker with water and pour it on the bit slowly to prevent splashing. After drilling, immediately tell the student pouring the water to touch the bit. It will be cool.

WHAT HAPPENED TO THE HEAT ENERGY? (Absorbed by the water). HOW DOES INDUSTRY USE THE SAME PRINCIPLE? (Uses oil) This same demonstration can be extended to movement of heat in the metal being drilled. The main point to develop is that heat travels from the hottest area to the coldest. WE MENTIONED EARLIER THAT THIS EXPERIMENT HAD HISTORICAL IMPORTANCE, SO LET'S READ ABOUT ONE OF THE SCIENTIFIC GIANTS OF HEAT EXPERIMENTATION.

Pass out sheet A - 22.

TEACHER DIRECTION A - 22

HEAT ENERGY

The reading activity is to reinforce the concept that heat is energy. After the students complete the reading, read the activity aloud with them while soliciting questions. The experiment by Count Rumford will need more explanation. The discussion of the experiment can develop the importance of comparison and that this is a valid means of experimentation recognized by scientists. Also make the point that science is continually changing due to questioning and experimentation.

Several words will need to be defined before the students begin reading. They are internal combustion engine, liquid, communication, associated with, influential, espionage, deported, and distinct.

The reading may stimulate interest to the point that outside reading and reports can be introduced. In this connection, students might read about Robert Fulton, a colorful scientist, and others such as James P. Joule, James Watt, Thomas Newcomen, and Dr. Rudolph Diesel.

The work that heat can perform is the most applicable community-related aspect. The following activities will investigate several of the applications of heat energy.

TEACHER DIRECTION A - 23

HERO'S ENGINE

Materials for groups of three: (B.B.W. Science Kit 6, Investigation 23)

1. Metal can (Hero's engine)
2. Can holder
3. Cord, 24 inches long (nylon)
4. Alcohol burner
5. Ring stand

Ask students to bring small cans to make their own Hero's engine. The holes in the cans must be very small. Use a non-twisted thread such as nylon. Remove any combustible material from the cans by washing with soapy water.

MANY CENTURIES AGO A GREEK IN ALEXANDRIA, EGYPT MADE A SIMPLE STEAM ENGINE USING HEAT ENERGY. LET'S TAKE A LOOK AT ONE. THIS SHOULD SHOW HEAT WILL DO WORK.

Pass out sheet A - 23.

HEAT ENERGY

Benjamin Thompson was born on a small farm in Massachusetts in 1753. He was a bright young man that moved from his farming community into the city where he became associated with influential people. When the Revolutionary War broke out in 1775 Mr. Thompson became a British spy, was caught by the Americans, and deported to England. The English government awarded him an important governmental post as head of the Bavarian War Department due to his espionage activities and his keen interest in science. The British government also gave Benjamin Thompson a noble title, Count Rumford. The Count was most interested in heat and read widely on the subject. Through experimentation he developed new theories and several inventions such as the drip coffee pot and the pressure cooker which are still used today.

Perhaps his greatest contribution was his theory related to heat. One day in Munich, Germany he was supervising the building of cannons. The cannons were made of long brass tubes that were bored out by long drill bits turned by horses, for then electrical power was not known. As the bit turned in the brass rod, it became hot enough to burn the men if accidentally touched. Count Rumford suspected the heat was due to friction, but the scientists during this time believed heat was a liquid called "caloric" and that the turning made the caloric run out. Therefore the heat was hot due to the caloric liquid. This seems foolish to us now, but it was a real problem in Count Rumford's time. You know they even believed when you build a fire you were being sprayed with this caloric liquid and this was what warmed you. The Count, a distinguished scientist, decided to test this theory. His experiment was very easy, but very important. He believed two things. First, if a liquid carried the heat, then it must have weight. Secondly, if caloric was once removed from the brass, it could not be heated up again because caloric was no longer present. Count Rumford wrote,* "It appears to me extremely difficult, if not impossible, to form any distinct idea of anything capable of being excited or communicated, in the manner heat was communicated in these experiments, except it be motion." He based this statement on his experiment in which he used brass turnings that had been bored, cooled, then reheated, and placed in water. Then he took the temperature of the water.

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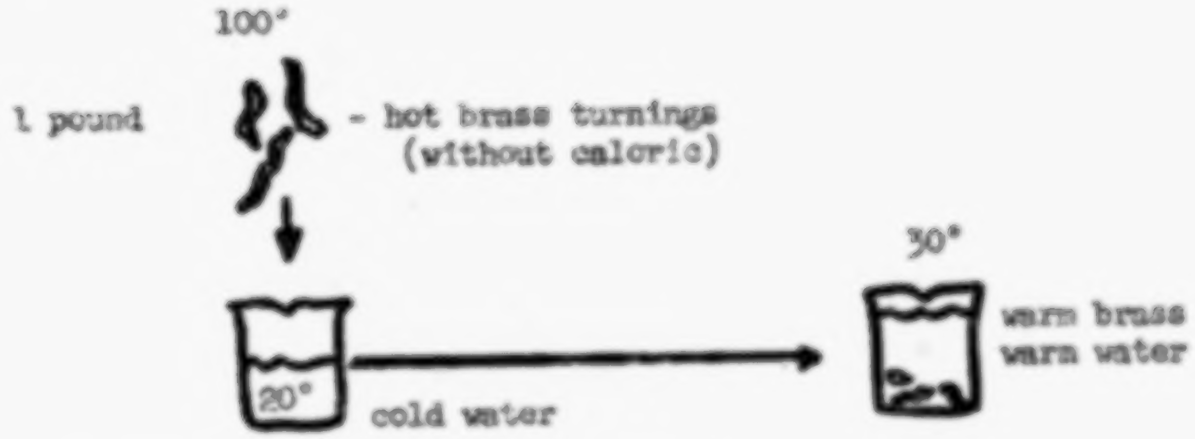
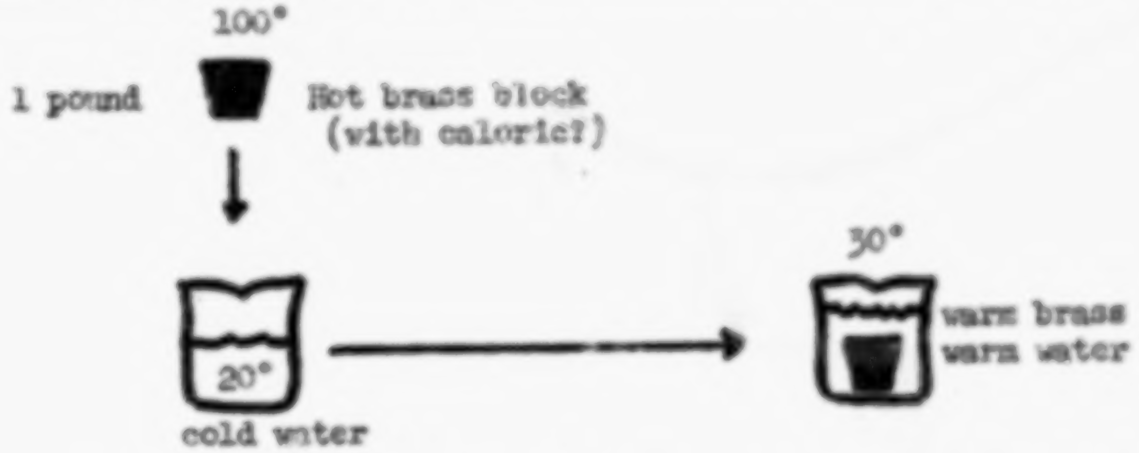
*Conant, James. Harvard Case Histories. Harvard University Press; Cambridge Mass. 1957, p 188.


100°
1 pound
- hot brass turnings
(without caloric)
30°
warm brass
warm water
20°
cold water

The brass block weighed the same as the turnings. Both were heated to the same temperature. The change in temperature of the water was the same in both cases. Therefore, the same amount of heat was transferred from the turnings as from the block. The caloric theory was proven wrong.


100°
1 pound
Hot brass block
(with caloric?)
30°
warm brass
warm water
20°
cold water

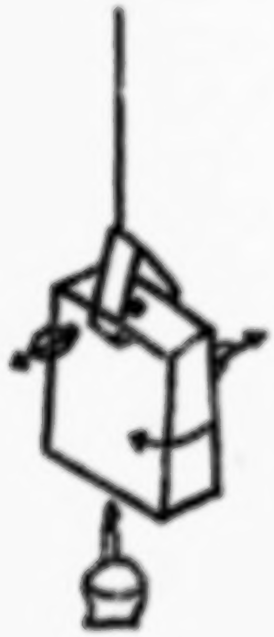
The mechanical energy of the drill was the source of the heat energy. Heat energy must be energy of motion.

Scientists came to recognize that Count Rumford was correct and as a result, science took a giant step. Soon after Count Rumford proved that heat is energy that can be transferred, the steam engine was developed and heat energy was put to work. Just think, the steam engine became the power source of the steam boat. Some made tractors for farmers using steam engines. Othe used the steam engine to run pumps, elevators, and to run nearly every conceivable device for which we now use electric motors and internal combustion engines. Even in atomic reactors, it is the heat energy that we use to drive our machines.

Teacher direction A - 23 (continued)

Instruct the students to follow your directions. Using a prepared acetate, instruct the students to assemble their apparatus, but do not start it until instructed to do so. After the apparatus is assembled, instruct them to follow directions as written and proceed with caution due to the fire.

After completing the activity, discuss the findings in a class discussion. The principle of action and reaction will be obvious. It may be of interest to the students that the same principle of the Hero's engine is used in turning space ships when in flight in outer space.



Topic 2 - Temperature can be measured by the Fahrenheit and Centigrade scales. It is a measure of the hotness of an object.

The term "temperature" should be an everyday word with the students, but only a few will understand the relation of temperature to heat. The following activities are to show that heat is energy and temperature is only the degree of hotness and coldness. In discussion, use the term energy after heat whenever possible, and degree of hotness when referring to temperature. This relation of heat to temperature is an abstraction and must be developed. Communication skills will develop via teacher led discussions as the students use definitive terms correctly. Do not attempt to explain the relation of heat to temperature until the students exhibit an understanding of the terms. Use thermometers that have dual centigrade and Fahrenheit scales. The students are to read the scales directly from the thermometer. It will be unwise to attempt calculations determining conversions unless the students wish to calculate conversions. The formulas are:

$F = \frac{9}{5} C + 32$ $C = \frac{5}{9} (F - 32)$ $1°C = 1.8° F$

STUDENT

A - 23

HERO'S ENGINE

Materials for groups of three:

1. Metal can
2. Can holder
3. Nylon string, 24 inches
4. Alcohol burner
5. Ring stand

Many centuries ago a Greek named Hero developed a steam engine. It is a good example of putting heat energy to work. You can make one if you wish. Some students have tournaments with Hero's engines to see who can make theirs go the fastest. Others have attached pulleys to see whose engine develops the most power. Your instructor may let you select a champion in Hero engine construction if enough would like to compete.

The Hero engine works on two principles: First, heat energy, and secondly, for every action there is a reaction. In this case steam is the product of heat energy and the action is the steam pushing out the little holes.

The instructor will give you directions in assembling the engine. Follow directions closely and do not light the burners until told to do so.

The alcohol burner is to serve as a source of heat energy. The water in the can will absorb the heat. The water turns to steam as it absorbs heat energy from the flame.

Put about one inch of water in the bottom of the can and screw the cap on the can tight so steam will not leak through the cap. It will take a few minutes after the burner is lit for the water to absorb enough heat to cause turning.

Count the number of turns the can makes in per minute each two minutes. One student is to watch the clock and make sure the counting starts at the right time and stops at the right time. One student is to count the turns, or revolutions. The third student is to record the data.

STUDENT
Page 2

A - 23

Start counting the revolutions per minute three minutes after the alcohol burner has been lit and placed under the Hero's engine. Make sure the tin can is not turning before placing the burner under the can. The can should be suspended by a thin monofilament cord.

TIME	WAIT 3 MINUTES	4	6	8	10	12	14	16	18	20
REVOLUTIONS per minute										

Make a drawing of the Hero's engine. With arrows show the direction of the turning and the direction the steam is blowing out.

How can you make the engine turn faster? List several ways and give your reasons for listing them. If you can't think of several ways, look in some books in your room. The quickest way is to look in the index in the back of a book. Look for Hero's engine or Hero.

Topic 2 (continued)

Graphing will be introduced in activity A - 25. Graphing can basically show trends and many times experimental errors will make some points invalid. These should be discarded. Approach graphing as a mathematical tool used to make predictions. Do not expect student success immediately. The students' previous unsuccessful experiences with graphing may create some apprehension. Illustrate on a prepared acetate how simple data may be graphed.

TEACHER DIRECTION A - 24

TEMPERATURE

Materials for groups of three:

1. 250 ml beaker
2. Thermometer
3. Ice
4. Alcohol burner
5. Ringstand

Do not be surprised if the students do not know which end of the thermometer to submerge for reading. Some students will have trouble locating the mercury column. The following activities will develop confidence by letting the students discover how to read the scales.

Caution students that thermometers are not to be used as an oral thermometer. The thermometer is not to be placed in a beaker and allowed to rest on the bottom of the beaker as the beaker is being heated (it will break).

WE HAVE STUDIED ABOUT HEAT ENERGY AND SEVERAL OF YOU HAVE MENTIONED TEMPERATURE. SO LET'S DO SOME WORK WITH TEMPERATURE. (Pass out the thermometers.) WHAT DO YOU CALL THAT THING I JUST GAVE YOU? Thermometer. WHAT DO YOU DO WITH A THERMOMETER? Accept all answers, but challenge any statement regarding heat by answering that heat is energy and must go from a hot area to a cold area, so what must temperature indicate? It indicates the direction of flow of the heat. At the most opportune time continue with, LET'S DEFINE TEMPERATURE AS THE DEGREE OF HOTNESS OR COLDNESS. NOW, LOOKING AT YOUR THERMOMETER, HOW HOT IS IT IN THIS ROOM? Place the prepared acetate of the thermometer on the overhead projector. Record all suggestions of temperature on the appropriate scale.

Accept all answers. Some acting here will increase interest. Promote discussion among the groups. Ask one group to check another group's reading. It will be most appropriate if you can ask a group that is giving Fahrenheit readings to check another group that is reading the centigrade scale.

EVERYONE LOOK AT THE TOP OF THE THERMOMETER. FIND THE LETTERS "C" AND "F". Pause.

WHAT DOES THE "C" STAND FOR? Centigrade. WHAT DOES THE "F" STAND FOR? Fahrenheit. THESE SCALES ARE TWO WAYS TO READ TEMPERATURE. IT JUST TELLS YOU HOW HOT OR HOW COLD THINGS ARE. LET'S SEE WHO IS THE HOTTEST, BOYS OR G

Teacher direction   A - 24 (continued)

GRIP THE THERMOMETER IN YOUR HAND. THREE MINUTES FROM NOW WE WILL TAKE A READING. Decide what scale to read during these three minutes. WHICH SCALE DO YOU WANT TO READ? CENTIGRADE OR FAHRENHEIT? (Discussion) After time is up, average all the girls readings and all the boys readings. Repeat the activity placing the thermometer in the bend of the elbow using the opposite scale. Stress the use of Fahrenheit since this is the most commonly used in the community. Make sure the students are proficient in reading both centigrade and fahrenheit scales.

AT WHAT TEMPERATURE DOES WATER FREEZE TO BECOME ICE? 32°F or 0°C. Accept all answers, but do not tell the students the correct answer. WELL, AT WHAT TEMPERATURE DOES WATER BOIL? 212°F or 100°C. Accept all answers, but do not tell the students the correct answer. LET'S FIND OUT.

Pass out A - 24

The students are to determine the freezing point and boiling point of water. They are also to take a reading every 2 minutes in order to graph the results. They are to read the thermometer with the bulb of the thermometer in the water.

The students may use the thermometer for a stirring rod, but they are not to leave the thermometer in the water without moving it. Caution the students to take readings accurately at the prescribed intervals.

The beakers are to be one-third full of ice water with only a small quantity of crushed ice to reduce the temperature of the water to the freezin point. When the temperature cools to 32°F, have the students remove all but one tiny piece of ice. Timing and heating should start when the temperature is approximately 32°F and a small quantity of ice remains.

After completion, go over the data using a prepared acetate of the temperature scale, A - 24, by writing in the times of each reading between the centigrade and Fahrenheit readings. Students are to follow using page 2 of A - 24.

The results are to be used in making the graph A - 25. Have the student make any needed changes in their data to insure success in making graph A - 2

STUDENT A - 24

TEMPERATURE

Materials for groups of three:

1. Thermometer
2. 250 ml beaker
3. Small quantity of ice
4. Alcohol burner
5. Ring stand

Temperature is a measure of hotness of an object. We know that if we put ice in water, the temperature should drop to 32° Fahrenheit and remain at this temperature as long as ice is present. This activity will show that the melting ice will cause the temperature of water to drop to 32°F, the freezing point of water. Then by heating the water over an alcohol burner, we can determine the boiling point of water.

The procedure must be followed carefully. Add ice water to the beaker until it is one-third full. Add a small piece of ice and stir it slowly and carefully with the thermometer until the temperature reaches 32° F. While waiting for the temperature to drop, adjust the ring stand to the proper height and light the burner. When the temperature drops to 32°F, record the exact time, minute, and second. Remove all but a tiny piece of ice and place the beaker on the ring stand over the alcohol burner.

While the water is heating, stir slowly with the thermometer. Do not ever let the thermometer rest on the bottom of the beaker; this may damage the thermometer.

To complete the table you must take a reading every 2 minutes and record the temperature in the proper space on the chart. Do be accurate, for these results will be used in the next activity.

Complete the table below. Be sure the temperature is recorded in the proper space under the correct time interval.

FREEZING TO BOILING

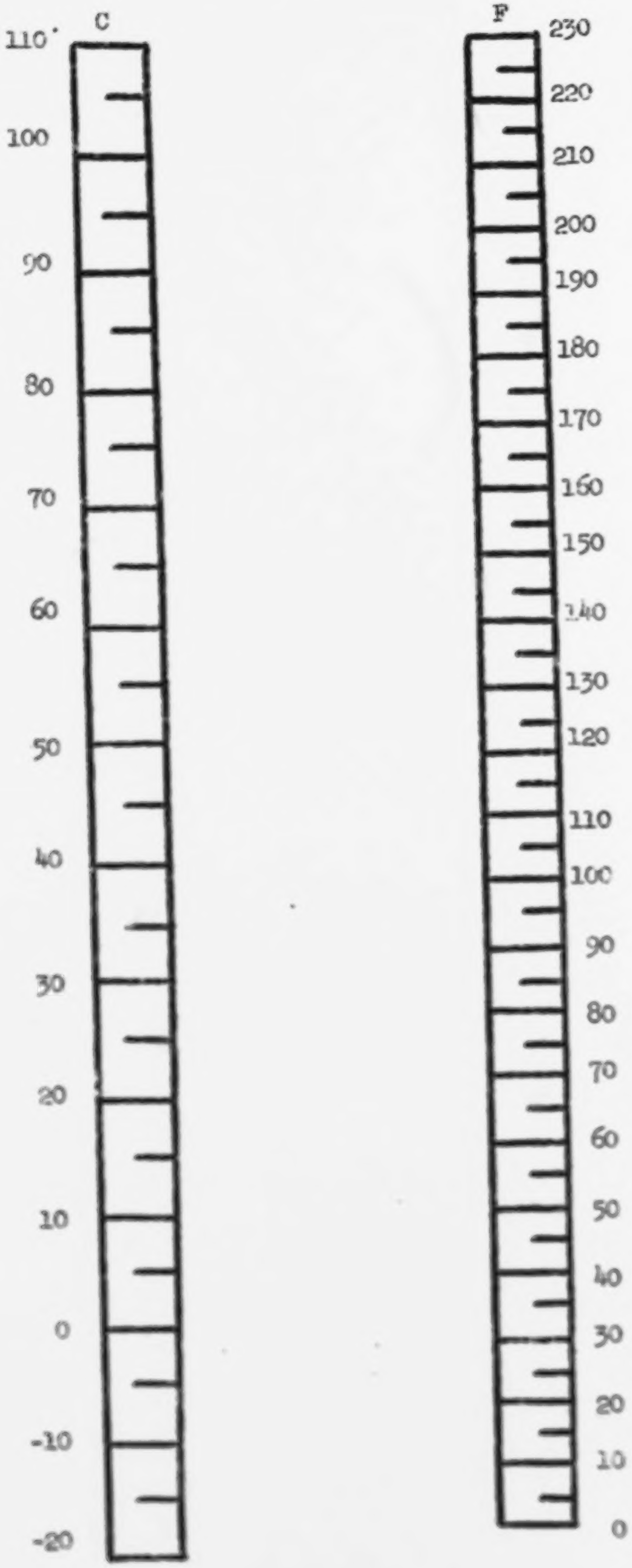
Intervals in minutes

TIME	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
TEMPERATURE Fahrenheit	32															

Starting time: Minute__________ Second__________

What is the boiling point of water?__________ How do you know?

A - 24


C
-10
-20
F

TEACHER DIRECTION A - 25

GRAPHING

This activity provides experience in making a useful tool for analysis of data. The graph will be a broken line graph and not a curved line. Starting at 32°F, the line should run horizontal for a short distance until the ice has melted. This line remains horizontal due to the absorption of heat energy in melting the ice. The line will then rise at about a 45° angle until the water starts to boil. The line again becomes horizontal and will remain so until all the water has boiled away. It remains constant due to the absorption of heat energy as liquid water changes to water vapor (steam).

The terms HEAT OF VAPORIZATION and HEAT OF FUSION should be introduced and used in the discussion and explanation, but should not be imposed on the students for memory.

Use the prepared acetate for recording the students' data for discussion. Using several student's data for showing the same results will be good. The difference in location of graph will reflect the differences in the quantity of heat produced by the different burners. The steeper the slope, the faster the water was heated, or the more heat energy the burner was producing. Also some groups may use more water than others. The smaller the quantity of water used, the steeper the slope will be.

Topic 3 - The Kinetic Molecular Theory of heat is a model of matter as consisting of moving molecules.

Models are useful in explaining what one observes. Models are in reality a visual picture of an idea. One visualizes how something works. An example is the model of the solar system which we use in accounting for the motions of the planets, day and night, seasons and the like. Likewise, molecular theory is a model of the nature of matter. It enables us to account for many phenomena such as expansion of things when heated, the pressure of a gas, the energy involved in change of state, the movement of heat energy, the spread of odors, et. al. We shall use it in extending our knowledge of heat energy.

The teacher may wish to demonstrate some of the activities in this topic rather than to use them as student activities.

STUDENT

A - 25

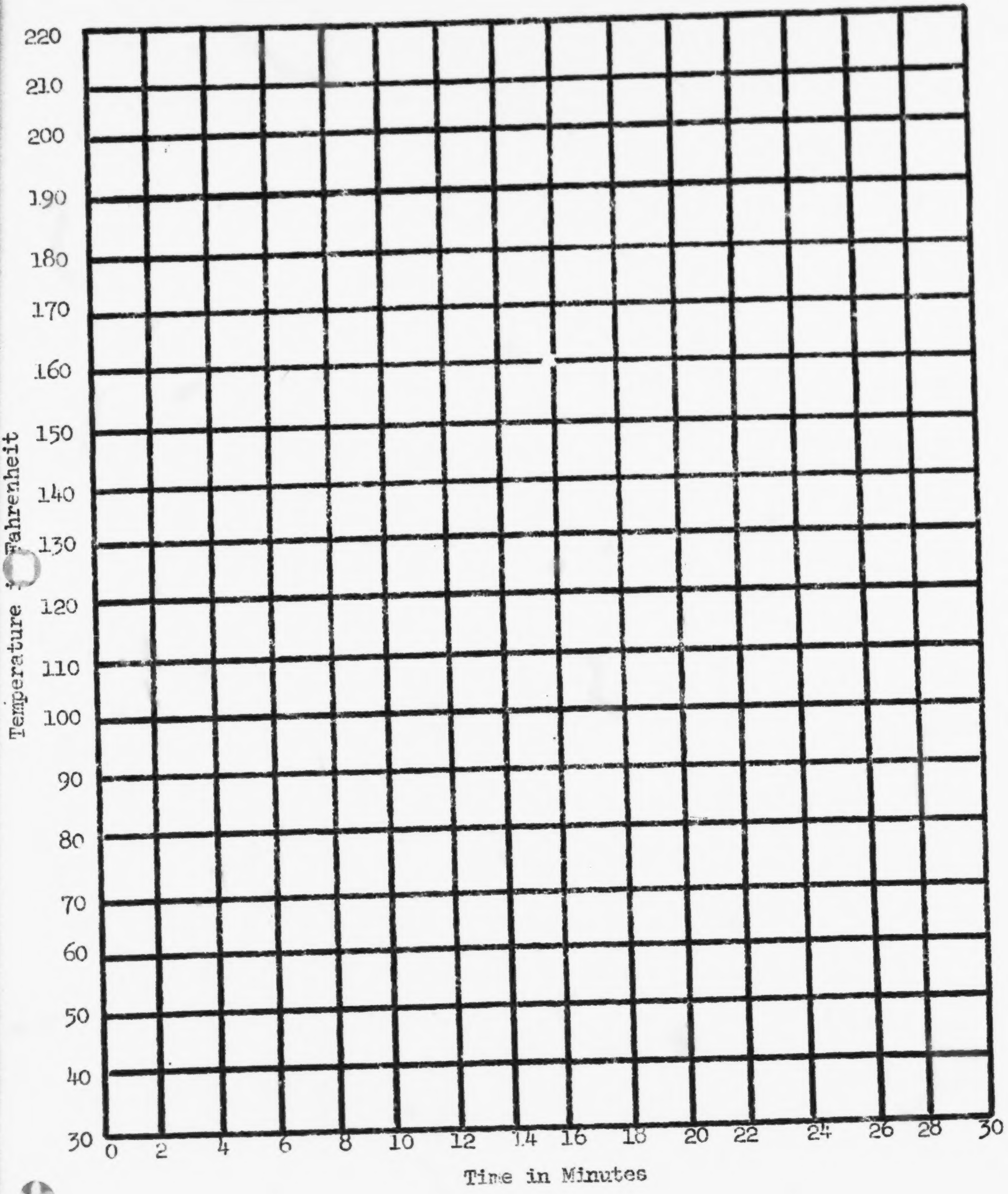
GRAPHING

The purpose of this activity is to convert the data you obtained from the previous activity into a more useful form. Graphing your results will make the data easier to interpret and much easier to read. It will enable you to guess what might happen if you continued the experiment over a longer period of time.

A graph consists of two parts, the horizontal and vertical axis. The horizontal axis runs across the page and the vertical axis runs up and down the page. On the graph you will be using, time (in minutes) will run from the left side of the page to the right side along the horizontal axis. The temperature starts at 32°F near the bottom of the page and increases as you go up the page along the vertical axis.

To locate a point on the graph, move horizontally across the page from the temperature recorded in your data. Next, move vertically from the proper time interval straight up the page. Where the two imaginary lines cross, make a point. Follow this same procedure for all of your data. After finding all your points, connect them with a straight line.

The graph for your group will not be the same as the graph your neighboring group will make. It should, however, have the same shape. Can you figure out why? Can you tell more from the graph you made than you can from the data recorded in your table?


220
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40
30
Temperature Fahrenheit
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Time in Minutes

TEACHER RESOURCE

The assumptions on which Kinetic Molecular Theory is based are as follows:

1. Matter in all its forms (gases, liquids, solids) is composed of extremely small particles called molecules. Molecules in turn are composed of atoms.

2. Molecules are in constant motion with speeds which increase with an increase in temperature.

3. Molecules are separated by spaces as though they were bouncing spheres. In solids, the spaces are small and motion is limited; motion consists largely of vibrations with the molecules keeping approximately the same relative position. In liquids the molecules move more freely shifting their relative positions (as when a liquid is poured), but clinging together. In gases the spaces are large; the rate of motion is greater; and the molecules tend to fly away from each other. When molecules collide they bounce from each other as if they were completely elastic with no apparent loss of energy.

4. The molecules attract each other with forces that act like gravitational forces.

5. When matter is compressed, the size of the molecules remains the same, but the spaces between the molecules are decreased. Thus a gas, with wide spaces between the molecules, is compressible.

6. The pressure of gases is produced by the moving molecules colliding with the walls of the container. When the motion and the number of collisions of the molecules are increased the pressure becomes greater.

Theories are useful to the extent that they enable us to build mental models to more effectively investigate and arrive at more meaningful conclusions. In building the model of molecular structure, start with the assumption that all matter consists of molecules which are in motion due to their energy, heat energy. The model of each of the three states of matter can be generalized as follows:

1. Solid
   The heat energy in solids is low and thus the motion of the molecules is slow. The molecules are close together with little space between them. This closeness of the molecules is why solids are heavy.

2. Liquids

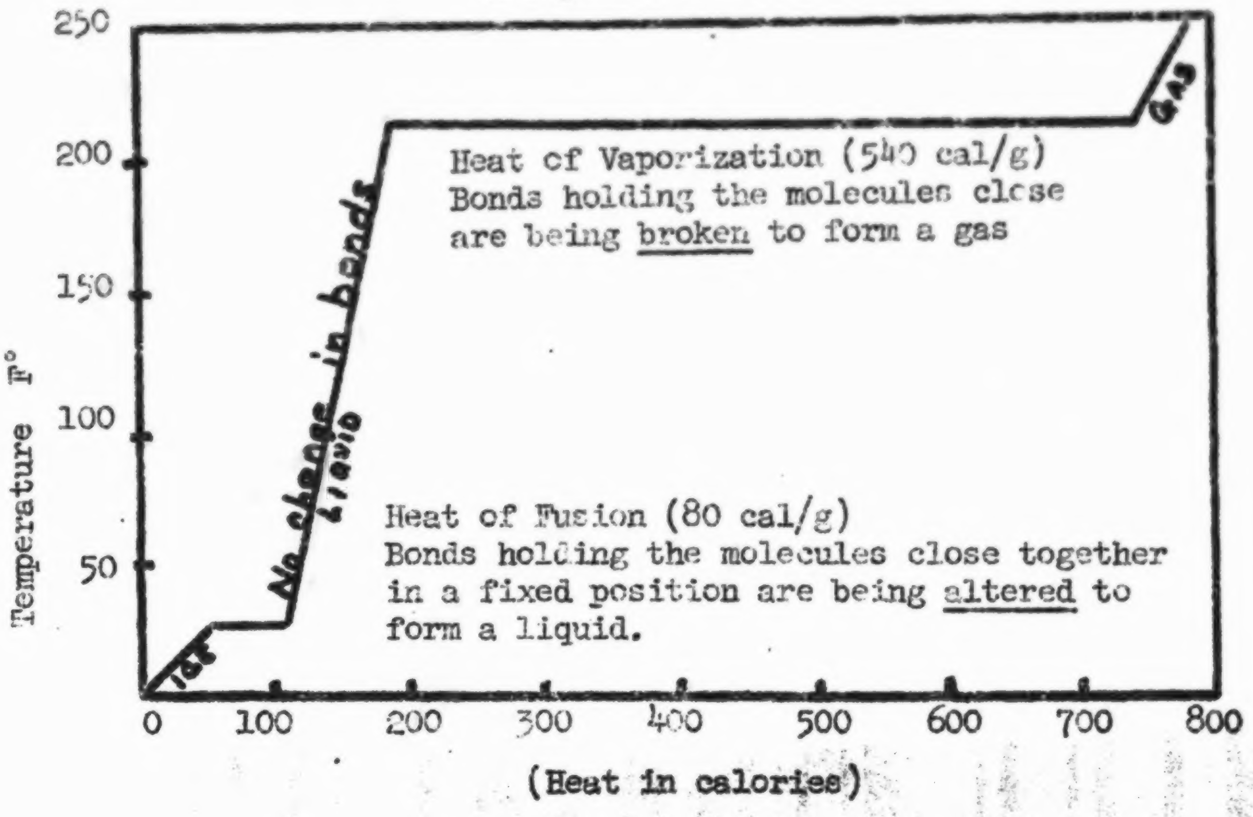
The heat energy in liquids is higher than in solids, and thus the motion of the molecules is faster than in solids. The molecules are not as close together with a little more space between them than in solids. Since there is more space between the molecules in liquids than in solids, liquids are lighter. (Ice is an exception because of its unique crystalline structure.)

3. Gases

The heat energy in gases is higher and thus the motion of the molecules is faster. The molecules are far apart with a lot of space between them. This vast free space explains why gases are so much lighter than solids and liquids.

The above statements have identified solids, liquids, and gases in terms of heat energy differences. The process of changing solids to liquids and liquids to gases requires a specific quantity of heat. The heat required to change a solid to a liquid (e.g. ice to water at 32°) without changing the temperature is called the HEAT OF FUSION. The heat required to change a liquid to a gas (e.g. water to steam at 212°) without changing the temperature is called the HEAT OF VAPORIZATION. The relationship of these quantities of heat, temperature change, and the accompanying change of state are shown on the graph below:

Change of State of Water



TEACHER DIRECTION A - 26

EXPANSION OF METALS

Materials for groups of three:

1. Glass jar and metal lid
2. Boiling water
3. Ball and ring expansion apparatus
4. Alcohol burner

This activity will make use of 'if - then' predictions to move the students toward abstract reasoning. Do not tell the students the expected outcome. The students are to compare data of two experiments showing the same principle. Read the prediction to the class, discuss it as long as there are questions, then pass out the activity for the investigation. Circulate among the students asking leading questions and supplying information when needed.

PREDICTION: IF MOLECULES ARE SEPARATED BY SPACES AS THOUGH THEY WERE BOUNCING BALLS, AND IF THE MOTION OF THE MOLECULES SPEEDS UP WHEN HEATED, THEN THE SUBSTANCE SHOULD GET BIGGER WHEN HEATED.

Investigations used to test this prediction are:

1. To see if heat makes solids expand, find how it affects a metal jar lid on a glass jar. To do this, have a student screw on this lid tightly. Then quickly heat the lid in hot water (boiling) and quickly try to unscrew it using a towel. Use care not to heat the glass jar. If taught as a demonstration ask:

   DOES THE LID COME OFF EASILY? Yes. HOW DOES THE HEAT AFFECT THE METAL LID? (Discussion) The molecules move farther apart resulting in expansion. The jar and the metal did not expand the same amount.

2. To see if heat makes solids expand, use a ball and ring. Alternately heat the ball then the ring to see if the ball will pass through the ring each time. This experiment works very well. Caution the students not to burn themselves.

STUDENT A - 26

EXPANSION OF METALS

Materials for groups of three:

1. Glass jar and metal lid
2. Boiling water
3. Ball and ring
4. Alcohol burner

In this activity you are to consider two conditions, draw conclusions, and support or reject a prediction. The prediction may or may not be right.

PREDICTION:

If molecules are separated by spaces as though they were bouncing balls, and if the motion of the molecules speeds up when heated, then the substance should get bigger when heated.

Investigation 1

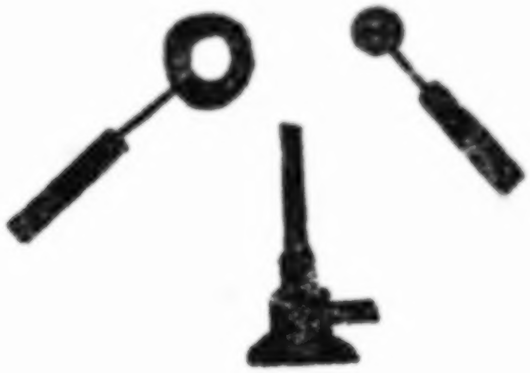
Screw the jar lid on the jar tightly. Submerge only the metal rim of the lid in boiling water, then immediately try to unscrew the lid. Remember you screwed the lid on very tight.

1. Was the lid easy to unscrew?______________________________
2. Did the metal expand or contract?__________________________
3. How does the metal expand?_______________________________

Investigation 2

The ball should barely pass through the ring when both are at room temperature.

1. If the ball is heated, will it pass through the cool ring?__________
2. If the ring is heated, will a hot ball pass through the hot ring?______
3. Will a cool ball pass through a hot ring?______________
4. How could the metal expand?______________________________________



DID INVESTIGATION 1 AND INVESTIGATION 2 SUPPORT THE ORIGINAL PREDICTION?

1. How did investigation 1 support the prediction?

2. How did investigation 2 support the prediction?

TEACHER DIRECTION

A - 27

STUNT: WEIGHT AND VOLUME

Materials for groups of three:

1. Bar and pin used in A - 1
2. 2 Locks
3. Ring stand
4. 8 washers (4 oz. each)
5. 500 ml flask
6. One-hole stopper
7. String (24 inches)
8. Alcohol burner
9. Plastic soda straw (fit rubber stop
10. 250 ml beaker

PREDICTION: IF MOLECULES ARE SEPARATED AS THOUGH THEY ARE BOUNCING BALLS, AND IF THE MOTION OF THE MOLECULES SPEED UP WHEN HEATED, THEN THE SUBSTANCE SHOULD GET BIGGER WHEN HEATED.

Investigation 1: Assemble the apparatus by placing the pin through the hole in the middle of the bar and clamping the pin to a ring stand. Add cold water to the flask until the water level is to the neck of the flask. Attach the flask to one end of the bar with the string, and balance with weights. If more water is needed, add until the bar is in balance. Mark the final cold water level on the flask. Replace the cold water with an equal volume of hot water. The hot water should be lighter.

Investigation 2: Add water to a beaker until two-thirds full. Insert a glass tube into a rubber stopper and fit it tightly into the empty flask. Invert the flask and dip the end of the tube into the beaker of water. Heat the flask until several air bubbles appear. Then remove the burner and allow the flask to cool. Some water should be drawn up into the tube as the air cools and contracts.

TEACHER DIRECTION

A - 28

CONDUCTION, CONVECTION, RADIATION

This activity is a reading activity on the methods of transferring heat. The teacher may want to read it aloud to the students or let them read it alone and then read it with them.

Many investigations can be planned to reinforce the reading material. The students' familiarity with heating and cooling can aid in planning activities outside the classroom. Examples are measuring temperatures of different colored liquids, of the inside of cars with different tops, and of the temperature of the air above sidewalks and lawns, et. al. The energy from the sun furnishes us with most of our heat as well as light.

Pass out A - 28

STUDENT A - 27

HEAT: WEIGHT AND VOLUME

Materials for groups of three:

1. Bar and pin used in A - 1
2. 2 hooks
3. Ring stand
4. 8 washers (4 oz. each)
5. 500 ml flask
6. One-hole stopper
7. String (24 inches)
8. Alcohol burner
9. Plastic soda straw (fit rubber sto
10. 250 ml beaker

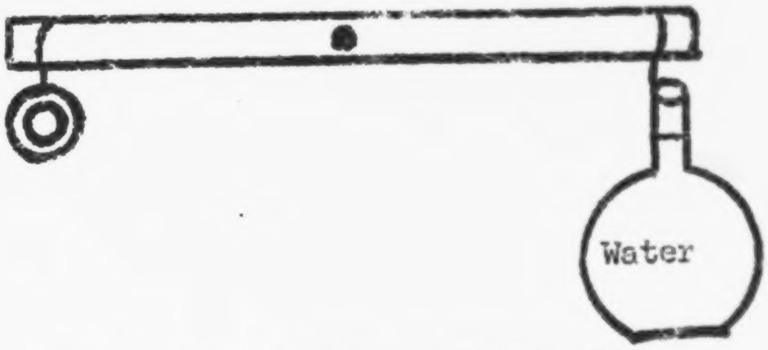
In this activity you are to consider two conditions, draw conclusions, and support or reject a prediction. The prediction may or may not be right.

PREDICTION:

If molecules are separated by space as though they were bouncing balls, and if the motion of the molecules speed up when heated, then the substances should get bigger when heated.

Investigation 1

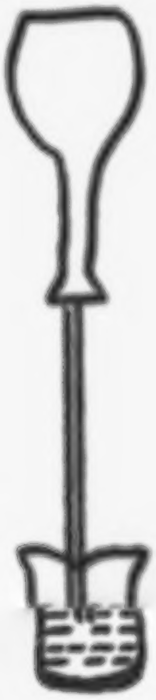
Suspend the meter stick at the mid-point from the ring stand. Add cold water to a flask until the water level is to the neck of the flask. Attach the flask to one end of the meter stick with a string and balance with weights. If more water is needed for balance, add water until the meter stick is in balance. Mark the final cold water level on the flask. Then pour out the cold water and replace it with an equal volume of hot water.



1. Was the cold water heavier or lighter?____________________
2. Why did the water expand when heated?____________________

Investigation 2

Add water to a 250 ml beaker until it is two-thirds full. Apply liquid soap to a glass tube and insert the glass tube in a rubber stopper and fit it lightly into an empty flask (full of air). Invert the flask and dip the end of the tube into the beaker of water. Heat the flask with an alcohol burner while holding the end of the tube under water until several air bubbles appear. Then remove the burner and allow the flask to cool, keeping the end of the tube in the water.



1. Where did the bubbles come from?____________________________
2. Why did the air expand when heated?__________________________
3. Why was the water drawn up into the tube?____________________

STUDENT A - 28

CONDUCTION, CONVECTION, RADIATION

Let's go swimming in John's swimming pool. Get your swim suit, towel, and hat and let's go. By the way, don't forget the sunburn lotion -- we'll need it. The sun is high and it's really hot outside today. Wish I had my sunglasses to reflect some of the light and heat.

"Hey, John, you must be crazy. You painted the diving board black and it's so hot I can't even touch it. Don't you know that dark colors absorb more heat than light colors?" Oh, well, anyone can make a mistake. John knew that people use white shingles on their houses because in the summer they are cooler, but - - - - -

Swimming makes me hungry so I brought along some hot dogs. John has a charcoal pit and some metal rods that we can use. How about a wiener roast? The heat is really radiating from the sun today. It's amazing how so much energy can get from the sun to the earth, especially since it has to travel through outer space and doesn't even have the wind to help it today.

"That's a pretty good fire you got there, Jack. Won't it go out unless you fan it? The wind isn't blowing today." Jack watched Hoss and Little Joe build a fire one time, and he figured out that heat rises when a fire is burning, cool air from all sides rushes in pushing the hot air from the fire upwards. This air circulation is called convection and, if you think a minute, convection explains why the wind blows. This is also why we direct the cool air of our air conditioner toward the ceiling. Hot air is lighter than cool air. So the hot air will be pushed up toward the ceiling by the cool air.

"Hey, John, I thought you were crazy, but now I know you are stupid. Your metal rods that we are using to roast the hot dogs with are getting hot. We can't hold them." John wasn't really stupid, he just forgot to get the wood handles for the rods. He knew that metal conducts heat and that some materials are better conductors than others. Wood doesn't conduct heat very well. That's why it is used for a handle.

A - 28

Let's try to remember some of the things we learned from this party. I'll list a few and you try to remember how it happened.

1. Dark colors absorb more heat than light colors. Light colors radiate more heat than dark colors.
2. Heat can travel by radiation which does not require any help from solid pieces or the wind.
3. Heat can travel by convection which is caused by the air circulating. Hot air is lighter than cool air. Hot air rises and cool air settles to the ground due to gravity.
4. Heat can travel by conduction where it is passed through a solid piece such as metal. All solids are not good conductors.

TEACHER DIRECTION

A - 29

HEAT OF FUSION

HEAT OF VAPORIZATION

Materials for groups of three:

1. Two 250 ml beakers
2. Two ring stands
3. Two gas burners
4. Two thermometers

The heat of fusion is the quantity of heat required to change a solid to a liquid without changing the temperature. The heat of fusion for ice is 80 calories per gram of ice. The change of state of ice from a solid to a liquid will take place at 32°F. The ice will absorb heat energy (80 cal./gram) until the molecules rearrange themselves to become a liquid, then the temperature will increase until the boiling point is reached. The calorie is defined as the quantity of heat energy required to increase the temperature of one gram of liquid water one degree centigrade. This means, if you have one gram of ice at 0°C, the molecular structure will prevent the solid from changing into a liquid until 80 calories of heat is absorbed by the molecules. When the water is in the liquid state, the temperature of water will rise 1°C when a calorie of heat energy is absorbed provided the water remains in the liquid state. The water temperature will continue to increase as heat energy is absorbed until it reaches 100°C. The temperature of the water will not increase above 100°C in an open beaker, but will continue to absorb energy. If the one gram of water is considered, at 100°C, the molecules will prevent the forming of water vapor until 540 calories of heat energy is absorbed; at this time the energy level in the molecules is so great the bonds break and the water escapes as a gas. The quantity of heat energy absorbed at 100°C, 540 cal./gram, which changes the water molecule relationship by breaking the bonds between the molecules and making the liquid change to a gas, is called the heat of vaporization of water.

The students need to understand the definition of a calorie. A demonstration using 100 ml of water in a 250 ml beaker, an alcohol burner and a thermometer is adequate. Set up the demonstration apparatus, for a class discussion. Write the definition of a calorie on an acetate, but make no reference to it until the demonstration is complete.

LET'S TALK ABOUT A DEFINITE QUANTITY OF HEAT ENERGY CALLED A CALORIE.

BUT FIRST, WHAT MAKES THE TEMPERATURE OF SOMETHING RISE? (Absorbs heat)

HOW MUCH HEAT MAKES WATER TEMPERATURE RISE 1°C? Calorie.

Do not give the students a technical definition of calorie. Time is not a factor in calories. Start the demonstration. Write on the acetate under the definition for the calculations. Have a student stir the water and tell you when the temperature rises 1°C. This will be 100 calories of heat energy absorbed (by definition). Explain why it took 100 calories to raise the temperature 1°C. Make up problems such as, how many calories are needed to raise 50 grams of water 2°C? 100 calories.

The student activity for heat of fusion and heat of vaporization will be more meaningful if calories are well understood. The " if - then" prediction will again be used. Follow the same procedure as used in A - 27.

PREDICTION: IF MORE HEAT IS REQUIRED TO CHANGE THE STATE OF A SUBSTANCE THAN TO CHANGE THE TEMPERATURE OF THE SUBSTANCE, THEN UPON HEATING, THE ICE AND RESULTING ICE WATER AT 0°C WILL REMAIN AT 0°C UNTIL THE ICE IS MELTED. THEN, UPON CONTINUED HEATING, THE WATER TEMPERATURE WILL RISE TO 100°C AND REMAIN UNTIL ALL THE WATER IS CHANGED TO STEAM.

(Discussion)

Pass out A - 29.

The students are to complete the table and graph the results.

Place ice in two 250 ml beakers and add water until 1/2 full. Stir with a thermometer until the liquid reaches 0°C. Remove the ice from one beaker, replacing the lost volume of water by adding ice water until both beakers contain an equal volume. Heat both of the beakers with two gas burners that are adjusted to produce the same amount of heat. Record the temperature each minute over a 30 minute period, record the results and draw a graph. On completion of the activity, clinch the concepts in a class discussion.

STUDENT A - 29

HEAT OF FUSION

HEAT OF VAPORIZATION

Materials for groups of three:

1. Two 250 ml beakers
2. Two ring stands
3. Two gas burners
4. Two thermometers

The heat energy a substance absorbs makes the temperature rise. Sometimes, however, the temperature does not rise even when a great deal of heat is absorbed. The calories, the amount of heat energy, absorbed by the molecules determine if a substance remains a solid, liquid, or gas. When heat is being absorbed one of two things will happen: (1) the temperature will rise and the phase (solid, liquid, gas) will not change, or (2) the temperature will stay the same and the phase (solid, liquid, gas) will change. The amount of heat required to change a solid to a liquid without changing the temperature is the heat of fusion. The amount of heat required to change a liquid to a gas without changing the temperature is the heat of vaporization.

This activity will show these relationships. You are to read the directions, complete the activity, record and graph the data, and support or reject the prediction.

Prediction:

If more heat is required to change the phase of a substance than to change the temperature of the substance; then upon heating, the ice and resulting ice water at 0°C will remain at 0°C until the ice is melted; then, upon continued heating, the water temperature will rise to 100°C and remain until all the water is changed to steam.

Set up two ring stands with two burners adjusted to produce equal amounts of heat intensity.

Number the beakers 1 and 2, then add ice and water to the two beakers until the water level is equal in both beakers -- about half full. Stir the ice water until they reach the freezing point, 0°C. Remove the ice from the first beaker and place it in the second beaker. Pour water out of the second beaker into the first beaker until the water levels are the same.

Place both beakers, at the same time, on the ring stands, stir gently while taking temperatures each minute for twenty minutes. Record the temperatures in the Table. After completion of the table, graph the results and interpret the data.

TEMPERATURE AND HEAT ABSORPTION

	Temperature each minute																			
Beaker Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. No Ice																				
2. With Ice																				

The graph will have two lines. Label the line 1 as "no ice", and label line 2 as "with ice".

1. How many minutes did it take the temperature in the beaker with "no ice" to start rising?____________________

2. How many minutes did it take the temperature in the beaker "with ice" to start rising?____________________

   Explain the answers in questions 1 and 2.

3. Which beaker of ice water absorbed the most heat?____________________

   How do you know?

4. Label the parts on the graph that represent the heat of fusion, temperature rise, heat of vaporization, ice, liquid, and the temperature where steam forms.

5. Does your data support or reject the prediction? Explain in detail.

UNIT 6

HEAT, CHEMICAL REACTIONS, AND BIOLOGICAL SYSTEMS

Topic 1 - The rate of chemical reactions is influenced by temperature. A biological system is the product of chemical reactions that maintain life. Temperature is a critical factor in perpetuating life.

TEACHER RESOURCE:

The rate of chemical reactions is influenced by heat in all cases. It is very critical in a biological system. The use of the incubator in hatching chickens will be used to demonstrate this influence of temperature on chemical reactions. Little reference should be made to descriptive terms such as metabolism, catabolism, et. al. The physical phenomenon should be stressed.

The following ideas are to be taught:

1. Life is the product of all the chemical reactions that occur in a living organism.

2. The temperature of the complex organisms we call birds and mammals cannot vary but a few degrees if their life is to be maintained. The references in the following discussions pertain to the chicken and man. In other organisms the temperature may vary somewhat more than in birds and mammals.

3. The enzymes are proteins that regulate the chemical reactions.

4. The rate of chemical reactivity of enzymes can be represented by a bell shaped curve with maximum activity at the top. This factor is most important in determining the optimum temperature for life.

5. A calorie is the amount of heat required to raise the temperature of one gram of water one degree centigrade. A kilocalorie, written Calorie equals 1000 calories.

6. The chemicals to be considered are proteins, carbohydrates (sugar and starch), and fats. A test for protein consists of adding nitric acid to an unknown solution. When proteins are present, they turn yellow. A test for sugar consists of adding Benedict solution and heat. A copper color indicates the presence of certain sugars. The test for starch consists of adding iodine to an unknown solution. When starch is present, the solution turns a deep purple. The test for fat consists of placing some of the unknown on a clean, unglazed, paper towel. A permanent translucent spot indicates the presence of fat.

Teacher resource (continued)

The last activities demonstrated heat energy and temperature as only a physical phenomenon. The physical activities are also important factors in life. The following activities will consider several of these physical aspects. A suggested calendar for the study of chick development can be found in the appendix.

PEOPLE HAVE SPENT MILLIONS OF DOLLARS ON HEATERS AND AIR CONDITIONERS TO KEEP WARM OR COOL. THEY DO THIS FOR ONE REASON; TO REMAIN AT THE SAME TEMPERATURE. WHAT TEMPERATURE DO YOU THINK IS THE BEST TEMPERATURE FOR A CLASSROOM TO BE? Write all answers on an acetate. WHY DO WE WANT A PARTICULAR TEMPERATURE? Few, if any, correct answers will result. WHAT IS SWEAT? It is mostly water. HOW DOES SWEATING AFFECT THE BODY? It cools the body. WHAT HAPPENS TO THE SWEAT? It evaporates. IF THE EVAPORATION OF SWEAT, (WATER) COOLS THE BODY, THEN THE EVAPORATION OF WATER SHOULD COOL A THERMOMETER. LET'S TRY IT. To demonstrate this cooling effect, wrap some cotton on the bulb of a thermometer, dip it in water, and have a student fan it to hasten the rate of evaporation. The temperature of this thermometer may then be compared to a dry thermometer at room temperature. How many degrees does evaporation cool the thermometer?

WHAT HAPPENS WHEN YOU PUT ALCOHOL ON THE SKIN? WHY ARE PATIENTS WITH A HIGH FEVER SOMETIMES GIVEN AN ALCOHOL BATH? WHICH WOULD LOWER THE TEMPERATURE MORE, ALCOHOL OR WATER? HOW CAN WE FIND OUT? Involve the class in planning the activity.

LET ME TELL YOU ONE OF THE THINGS SCIENTISTS BELIEVE ABOUT LIFE. FIRST, LIFE IS THE RESULT OF ALL THE CHEMICAL REACTIONS THAT MAINTAIN A LIVING ORGANISM. WHAT ARE SOME OF THESE REACTIONS? LET ME GIVE YOU A START: RESPIRATION, LOCOMOTION. List on acetate class suggestions. The term organism will need to be defined.

LET ME ASK YOU ANOTHER QUESTION: WHAT IS FOOD? Discussion. SCIENTISTS SAY THAT FOOD IS A MIXTURE OF CHEMICALS. DO YOU AGREE? Discussion. LET'S CONSIDER THREE TYPES OF FOOD: PROTEINS, CARBOHYDRATES, AND FATS. YOU HAVE AL HEARD OF THESE, AND KNOW YOU HAVE TO EAT THESE FOR A GOOD, BALANCED DIET, BECAUSE THESE PROVIDE US WITH ENERGY, AND PROTEINS ARE ESSENTIAL FOR GROWTH AND REPAIR. JUST EATING THESE HOWEVER, WILL NOT KEEP YOU ALIVE. YOU MUST ALSO MAINTAIN A CERTAIN BODY TEMPERATURE; AND, OF COURSE, DRINK PLENTY OF WATER. WHAT TEMPERATURE DO MOST PEOPLE MAINTAIN? (98.6°F) Discussion. This temperature is best for chemical reactions of the body to take place. If a person gets too hot or too cold, death will result. If you burn your

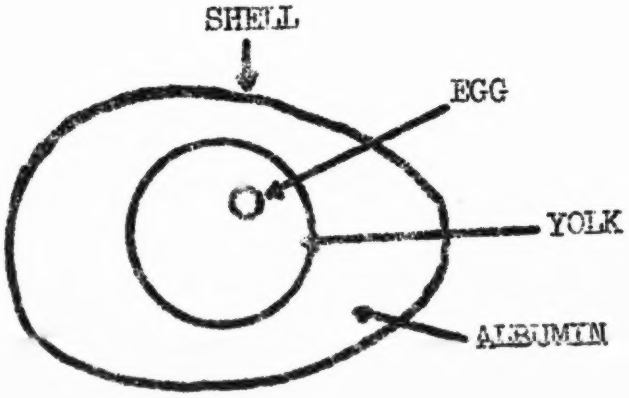
Teacher resource (continued)

finger, the cells of your skin are killed. If you touch your tongue to a cold ice tray, the skin on the tongue will not only stick, but be destroyed. Other examples may be suggested by the class. Stress that the temperature has a direct relation to the chemical reactions causing the death.

LET'S CONSIDER THESE CHEMICAL REACTIONS IN A REAL LIFE SITUATION. HOW MANY OF YOU HAVE SEEN A CHICKEN EGG? HOW MANY OF YOU KNOW WHERE LITTLE CHICKS COME FROM? THE CHICKEN OR THE EGG? Discussion. Both answers are correct. LET'S RAISE SOME LITTLE CHICKS, AND DURING THIS TIME FIND OUT AS MUCH AS WE CAN ABOUT HOW THEY DEVELOP. WHAT WILL WE NEED BEFORE WE START? LET ME TELL YOU SOMETHING ABOUT EGGS THAT YOU WILL NEED TO KNOW. PERHAPS YOU ALREADY KNOW MOST OF THESE THINGS, BUT LET'S MAKE SURE. Write on the overhead projector and discuss each item.

1. Parts

	Structure		Function
a.	Shell	a.	Protection and insulati
b.	Yolk	b.	Food for the embryo
c.	Albumin or white	c.	Food for the embryo
d.	Egg (a white dot on the yolk)	d.	The fertilized egg develops into the chi



2. Incubation requirements
   - a. 21 days at 99°F. (longer at lower temperatures)
   - b. Turning the eggs in the incubator every 4 to 8 hours
   - c. Adequate air and moisture

After discussing these points, have each group of students write their names on six eggs with a pencil and place the eggs in an incubator. Let the students ask questions about the incubator. Have discussions concerning the physical features of the incubator. Many excellent points can be made concerning thermostats, humidity, insulation, etc. The following activities will stress the parts of the egg along with the protein, carbohydrate, and fat content of foods.

Teacher Resource (continued)

The procedure for opening eggs should be demonstrated. If the eggs are cracked very gently the shell may be removed for observation of the membranes. The students should enjoy this procedure and can compete to see who can remove most of the shell without releasing the albumin and yolk. When removing the young chick embryos, always release the contents of the eggs into luke warm water. A petri dish serves well as a container to observe the embryos.

The eggs will require 21 days of incubation at a temperature of 99°F. A two degree variation is all that should be allowed. The development of fertile eggs is inhibited at 55°F. Embryonic development will begin when the temperature is increased to 99°F. A prolonged variation of more than 2°F either way will retard the growth or kill the embryo. Another critical factor is the turning of the eggs. This should be done ideally every 4 hours. If the eggs are not turned, hatching will not occur. However, some development will take place. Involve class members in the turning schedule.

TEACHER DIRECTION A - 30

THE CHICKEN EGG

Materials for groups of three:

1. Egg
2. Forceps
3. Petri dish
4. Luke warm water
5. Ruler
6. Scissors
7. Paper towels
8. 250 ml beaker

Stress at the beginning of this activity the importance of heat and chemical activity. The eggs prior to incubation were kept at 55°F and little, if any, reaction took place, therefore, no embrionic development. Before incubation the fertilized eggs look just like unfertilized eggs. In this activity the students are to open an unfertilized egg to see its parts. Some students may want to put some unfertilized eggs in the incubator for comparison. Be sure to mark them for identification. The parts of the egg the students are to observe are the shell, membrane, albumin, chalaza, and the tiny embrionic egg. The students are to gently crack the shell and remove a portion of the shell to expose the membrane. After observing the membrane they are to break it and pour the contents into a petri dish to make observations and drawings of what they observe.

Teacher direction A - 30 (continued)

A small amount of luke warm water should be in the petri dish. A prepared acetate of the parts (labeled) are to be placed on the overhead projector, without making reference to it. This will serve as a guide. Do not explain the parts or their function until after the activity.

LET'S INVESTIGATE AN EGG BY OPENING IT TO SEE WHAT IS INSIDE. YOU ARE TO MAKE A DRAWING AND IDENTIFY THE PARTS.

Pass out A - 30.

Before the students begin work read over the directions with them very carefully. Create an atmosphere of competition in who can peel most of the shell away before the inside of the egg spills. Caution the students to work over the petri dish and towels at all times.

After the students complete the activity, assemble for a class discussion There should be confusion concerning the function of the parts. Using the prepared acetate, discuss each part:

1. Shell - protection and allow gases to enter and leave the egg
2. Yolk - food and hold the embryo egg
3. Membrane - Allow gases to enter and leave the egg
4. Albumin - food
5. Chalaza - hold the yolk (Note: This will be broken when the egg is poured into the petri dish)
6. Air sac - a reservoir of air
7. Embryo egg - the fertilized portion that will develop into the chicken

WE HAVE DECIDED THAT THE YOLK AND ALBUMIN PROVIDE THE FOOD FOR THE EMBRYO. WHY WOULD THE YOUNG EMBRYO NEED FOOD? Discussion. TO OBSERVE THE DEVELOPMENT OF THE EMBRYOS, WE ARE GOING TO OPEN THE EGGS ON THE FOLLOWING DAYS: 5th DAY, 9th DAY, 14th DAY, AND 19th DAY. REMEMBER WHAT YOU SEE. EACH OF THE FOLLOWING ACTIVITIES ARE TO BE KEPT FOR REFERENCE.

If time permits, have the students dilute formaldehyde to a 10% solution, wash the bottles, and prepare to start preserving specimens. If time is too limited, do this the next day. Each group will need 4 bottles. Baby food jars are suitable.

TEACHER DIRECTIONS A - 31

FIVE DAY EMBRYO

Materials for groups of three:

1. Egg
2. Forceps
3. Scissors
4. Petri dish
5. Luke warm water
6. 4 paper towels
7. Ruler
8. Bottle for specimen
9. 10% solution formaldehyde

STUDENT

A - 30

THE CHICKEN EGG

Materials for groups of three:

1. Egg
2. Forceps
3. Petri dish
4. Luke warm water
5. Scissors
6. Paper towels
7. 250 ml beaker

You are now starting to study one of the most interesting parts of science, 'how life begins and develops'. Life in the chick egg begins with the small white spot on the yolk. It really isn't hard to see. From this little white spot a chick will develop, grow, and become an adult chicken. In the following weeks you will open many eggs and follow the development of the embryo very closely. Today's activity will permit you to see the parts of the egg. Follow the directions very closely and use good laboratory procedures.

Obtain an egg from your instructor. To determine if the egg is fresh or not, place the egg in a beaker of water. If it sinks to the bottom it is fresh. If it floats, it is not a fresh egg. Why do you suppose a stale egg floats? Is your egg fresh?___________ How do you know?

After determining if your egg is fresh or not, begin your investigation. You are to make a drawing and label the parts. Tell the function of each part.

Very gently crack the large end of your egg. Then with your forceps or finger nail peel part of the shell away. Be very careful not to break the thin membrane just under the shell. At the large end of the egg, a small air sac separates the shell from the membrane. The air sac is really a very small portion of the fresh egg. At all other places on the egg shell, the membrane is just beneath the shell.

After seeing the membrane, empty the egg into some luke warm water in a petri dish for observation. Make a drawing of what you see, label the parts, and tell what you think each part does.

A - 30

The parts you are to identify are:

1. Shell
2. Membrane
3. Yolk
4. Albumin
5. Embrionic egg
6. Chalaza (a white cord attached to the yolk)

Make a drawing below. Write what you think each part does beside the name of the parts on your drawing. Remember, life requires air, food, warmth and protection.

How long is the embrionic egg?______________inches

When you complete this activity, dispose of the eggs as your instructor directs.

Teacher direction A - 31 (continued)

This activity will be the first proof that growth is really occuring. Students will be amazed at the growth that has taken place. The heart should be beating and the outline of the chicken will be seen. It is important that the food (chemicals) is being consumed and used. Heat is also critical or the reactions will stop, and death will occur. Use the terms proteins, carbohydrates, and fats at every opportunity.

TODAY WE ARE TO OPEN THE EGGS FIVE (5) DAYS AFTER INCUBATION HAS BEGUN. IT IS IMPORTANT THAT YOU USE GOOD LABORATORY TECHNIQUES. REMEMBER TO CRACK THE EGG GENTLY ON THE LARGE END, THEN PEEL THE SHELL BACK CAREFULLY. EACH GROUP IS TO PICK UP ONE EGG AND FOLLOW DIRECTIONS AS THEY ARE WRITTEN. BE SURE TO MAKE AN ACCURATE DRAWING. IF YOUR EMBRYO HAS NOT STARTED TO DEVELOP, SEE ME AS QUICKLY AS POSSIBLE FOR ANOTHER EGG. WHY MIGHT SOME EMBRYOS FAIL TO DEVELOP? DO NOT PLACE THE EMBRYO IN A PETRI DISH WITHOUT FIRST ADDING WARM WATER. NOTICE THE SIZE OF THE YOLK TO SEE IF THE EMBRYO IS USING ANY OF THE PROTEINS, CARBOHYDRATES, OR FATS AS FOOD. SELECT ONE MEMBER OF YOUR GROUP TO REPORT WHAT YOU OBSERVE.

Pass out A - 31.

Work very closely in supervising this activity. Continually ask questions and encourage students to observe other group's specimen.

After completion of the activity reassemble for a class discussion. Using the prepared acetate for A - 26, go over the activity and draw in the changes that have taken place. If some one of the students likes to draw and has good results, let him draw the changes on an acetate prior to the class discussion.

During the discussion set the stage for testing proteins, carbohydrates, and fats. This can be accomplished by stressing the need for food by the embryo. Use the terms carbohydrates, sugar, starch, proteins, and fats at every opportunity.

TEACHER DIRECTION A - 32

PROTEINS

Materials for groups of three:

1. Hard-boiled egg (unfertilized)
2. Nitric acid, concentrated
3. Test tube
4. Alcohol burner
5. Ammonium hydroxide

The following test is a standard test for proteins. The chemical reaction will give a yellow color. It is important to remember that Nitric acid is DANGEROUS. Note: always add acid to water when diluting. Let the students hard boil the eggs the day before the activity or before class time. Make sure the eggs are hard boiled by boiling them at least 15 minutes.

STUDENT A - 31

FIVE DAY EMBRYO

Materials for groups of three:

1. Egg
2. Forceps
3. Scissors
4. Petri dish
5. 4 paper towels
6. Luke warm water
7. Ruler
8. 250 ml beaker

Your eggs have been in the incubator for five days. What do you think has happened? Is the heart beating? Is the embryo eating food? Is the yolk any smaller? Take a look and see!

Crack the egg gently on the large end and remove all of the shell you can before breaking the membrane. After removing the shell, cut the membrane with your scissors and pour the egg into a petri dish that contains warm water. The warm water will prevent the cooling of the embryo too fast and will prolong the life of the embryo for examination.

Remember to work over the paper towels and petri dish at all times.

Make a drawing of the egg and label the parts as you did in the last activity, A - 30. Then answer the questions at the end of the activity. Select one member of your group to report what you observe.

Make your drawing and label the parts here.

A - 31

Answer the following questions:

1. What is the temperature of the water in the dish?____________________
2. How many times each minute is the heart beating?____________________
3. As the temperature of the water goes down, what happens to the rate of heart beat?

4. How would an increase in the temperature of the water affect the rate of heart beat?

5. Measure the embryo. How long is it?____________________inches.
6. Were the eyes starting to form?______________
   How can you tell?

7. Can you see any blood vessels?__________________
   Where are they located?

8. Is the embryo alive?_______________
   How can you tell?

9. Record the following information.
   a. Temperature in the incubator._________________
   b. Number of eggs opened today by your group.______________
   c. Date______/______/______
   d. Do you think your eggs are developing as they should?_________
      How can you tell?

Teacher direction A - 32 (continued)

A PROTEIN IS A CHEMICAL SUBSTANCE THAT CAN BE USED FOR FOOD. THE LACK OF CERTAIN PROTEINS IN YOUR DIET WILL CAUSE DEATH. SO THE YOUNG CHICKEN EMBRYO MUST HAVE PROTEIN. LET'S TEST FOR PROTEINS AND SEE IF THE EGG HAS PROTEINS PRESENT. LET'S GO OVER THE DIRECTIONS FOR A-32 TOGETHER. WE ARE GOING TO USE CONCENTRATED NITRIC ACID AND IT IS DANGEROUS. IF YOU GET ANY ON YOU, TELL ME IMMEDIATELY. YOU MUST USE EXTREME CAUTION. THE ACID WILL REMAIN ON THE INSTRUCTOR'S DESK AT ALL TIMES AND ONLY BE USED UNDER TEACHER DIRECTION.

Pass out A - 32.

Read the directions with the students. Make sure they know what to expect. Two ml of nitric acid is to be added to some chips of egg white in a test tube and heated gently over an alcohol burner. It should turn yellow. To deepen the color, add a little of ammonium hydroxide and watch the yellow turn to an orange color.

If the students get any of the acid on their skin, it will turn yellow indicating they have protein in their skin. Wash the hands in water with soap. The yellow spots will wear off.

After the students complete the activity and clean up the laboratory, reassemble for group reports and a class discussion. Go over the material and answer any questions that may arise. Stress the heat relationship in the incubator and reactivity of the chemicals. Also mention that chemical reactions give off heat and this adds extra heat from which the organisms can use for energy.

Allow the students to observe eggs in the incubator each day.

TEACHER DIRECTION A - 33

CARBOHYDRATES

Materials for groups of three:

1. Test tube
2. Alcohol burner
3. Karo syrup
4. Piece of potato
5. Piece of bread
6. Benedict's solution
7. Iodine (diluted with alcohol)
8. Scalpel

Carbohydrates, like proteins, are one of the chemicals used for food. A well balanced diet requires carbohydrates. The tests are very simple and very good results can be anticipated. The tests are as follows:

SUGAR
Benedict's solution + Karo syrup (sugar) + Heat ⟶ Copper color

STARCH
Iodine solution + Bread or Potato (starch) ⟶ Deep Purple Color

STUDENT

A - 32

PROTEINS

Materials for groups of three:

1. Hard-boiled egg
2. Nitric acid, concentrated, (HNO_3)
3. Test tube
4. Alcohol burner
5. Ammonium hydroxide (NH_4OH)

The test for protein is a simple test. Proteins are large molecules that are found in every living organism. Organisms have different quantities of proteins but they all have proteins. Scientists believe that the energy and the abilities of people are based on the proteins within their biological system. Certainly, much has been and is being done to investigate these relationships. It is certain, however, that the lack of certain proteins may cause illness or death.

The following test is just one of the many tests for proteins. If you are interested in other tests, a good book for reference is A Sourcebook for Biological Science by Evelyn Morholt, Paul F. Brandwein, and Alexander Joseph, published by Harcourt, Brace, and World. Your library should contain this book. Look in the index under "Protein Tests" to find the page number where the tests are located.

The following test is to be performed on the white of an egg that has been hard boiled. Remove several small pieces of the albumin and place them in a test tube. Then add a small quantity of nitric acid to the test tube. After adding the acid, light the alcohol burner and heat the contents of the tube very slowly by moving the test tube back and forth through the flame. Always remember to point the mouth of the test tube away from yourself and your partner. If proteins are present, a yellow color will appear on the albumin. After the yellow color appears, let the test tube cool and add a little ammonium hydroxide.

A reaction may be written for this experiment:

Nitric acid + Protein → Yellow color
+
Ammonium hydroxide → Orange color

When you have finished the experiment, answer the following questions.

1. Is protein present in the albumin?______________
   How do you know?

2. Why is heat needed to cause the reaction of proteins and nitric acid?

3. Do you think the chicken embryo uses some of the albumin for food?
   ____________ Why?

4. Do you think the white of an egg is good in your diet?____________
   Why?

Teacher direction A - 33 (continued)

A corn starch solution can also be used in place of the potato or the bread. Corn starch will be used later to show enzyme reaction and it is suggested that the corn starch not be used at this time.

WHAT THREE FOODS HAVE WE TALKED ABOUT? (Proteins, carbohydrates and fats) WHAT IS THE TEST FOR PROTEINS? Discussion, review test. LET'S TEST FOR CARBOHYDRATES. CARBOHYDRATES ARE DIVIDED INTO TWO GROUPS, SUGARS AND STARCHS. BOTH ARE SOURCES OF ENERGY.

There is danger in the use of Iodine and Benedict's solution if taken internally. Permanent staining will occur if iodine gets on clothes. Sometimes alcohol will prevent staining if applied liberally and immediately.

Pass out A - 33.

Let the students read the directions and work independently. Circulate among the groups correcting techniques and asking questions.

After the students complete the activity, reassemble for a class discussion. Go over the material and answer any questions that may arise. Stress the heat relations in the incubator and the reactivity of the chemicals.

TELL ME SOMETHING, WHAT WOULD HAPPEN IF YOU SPILLED IODINE ON YOUR SHIRT? It would turn purple and prove starch was present. WHAT WOULD HAPPEN IF YOU SPILLED BENEDICT'S SOLUTION ON YOUR HAND? Nothing, heat must be added to start the reaction. WHAT WOULD HAPPEN IF YOU SPILLED NITRIC ACID ON YOUR ARM? It would turn yellow proving proteins were present.

The next test will be for fats. This test is not very dramatic, but extra time can be used wisely in preparing for A - 33.

TEACHER DIRECTION A - 34

FATS

Materials for groups of three:

1. Olive oil
2. White paper towel
3. Test tube
4. Carbon tetrachloride (CCl_4)
5. Hamburger meat
6. Eye dropper

This activity will show a simple test for fats. Many different types of fats can be used; mineral oil, fat meat, hamburger meat, lard, cooking oil, cooking grease, etc. The fat will leave a translucent spot on the paper towel that is readily observable when held up to the light. Water will also cause a translucent spot, but will not be permanent after drying. The students should be warned concerning this factor, and a drying period allowed. Using small quantities of the food samples will reduce drying time.

STUDENT

A - 33

CARBOHYDRATES

Materials for groups of three:

1. Test tube
2. Alcohol burner
3. Karo syrup
4. Piece of potato
5. Piece of bread
6. Benedict's solution
7. Iodine solution
8. Scalpel

We are considering three basic food substances, called proteins, carbohydrates, and fats. We know how to test for protein, so now let's consider the test for carbohydrates. Carbohydrates are divided into two groups called sugars and starches. Let's consider each separately.

Test for sugar

Obtain some Karo syrup from your instructor in a test tube. Add four drops of Benedict's solution to the syrup. Is there a reaction? Next, heat the syrup and Benedict's solution over the alcohol burner by passing the test tube in and out of the flame very slowly. Remember to keep the test tube pointed away from yourself and your partner. You will see a very definite color change.

What color did the mixture turn?____________________

Was heat needed?________________ What does the heat do?____________

____

What color is the Benedict's solution?____________________

Do you believe copper is in the Benedict's solution?_________ Why?

Test for starch

Remove a small piece of potato with a scalpel and place it on a paper towel. Add one drop of iodine solution. Next, place a small piece of bread beside the potato and add one drop of iodine solution to the bread.

What color did the potato turn?________________ The bread?__________

What color is the iodine solution?________________

If no starch was present, what color would you expect?_____________ Why?

If you had toast, pancakes, and eggs for breakfast, would you have starch, sugar, and proteins?__________ How do you know?

When you clean up your laboratory, make sure all of the iodine is removed from the table. If you cannot wipe it up, alcohol will remove it.

Teacher directions A - 34 (continued)

WE HAVE TESTED FOR TWO OF THE THREE FOODS WE HAVE TALKED ABOUT -- PROTEINS AND CARBOHYDRATES. WHAT IS THE TEST FOR PROTEIN? (Discussion) WHAT IS THE TEST FOR SUGAR? (Discussion) WHAT IS THE TEST FOR STARCH? (Discussion) NOW, LET'S TEST FOR FAT. THE TEST FOR FAT IS TO PUT AN UNKNOWN MATERIAL ON WHITE ABSORBANT PAPER AND ALLOW IT TO DRY. IF AFTER DRYING, A TRANSLUCENT SPOT REMAINS THROUGH WHICH YOU CAN SEE MORE LIGHT PASSING THROUGH, THEN FAT IS PRESENT. IF THE SPOT GOES AWAY WHEN IT IS DRY, THEN FAT IS NOT PRESENT. (Discussion)

Pass out A - 34

There are really two tests. One is just placing olive oil on a paper towel, wait 10 minutes, then look at the spot. The second test is to use a solvent to remove the fat, carbon tetrachloride, and then testing the mixture. The carbon tetrachloride will evaporate leaving a translucent spot of fat on the paper.

YOU HAVE BEEN GIVEN THE ACTIVITY TO DETERMINE IF FAT IS PRESENT. THERE ARE TWO TYPES OF FATS, SATURATED FATS WHICH ARE SOLID AND POLY-UNSATURATED FATS WHICH ARE OILS, OR LIQUIDS. Discussion. YOU ARE TO TEST FOR BOTH. FOLLOW THE DIRECTIONS CLOSELY. (Discussion) Tell the students to read the directions and proceed to test for fats.

After the students complete the activity, reassemble for a class discussion. Discuss the results of the tests for fats. The eggs are to be opened the following day and the students will be testing the eggs for proteins, carbohydrates, and fats.

If some students finish early, they can begin preparing for A - 35. All of the specimen jars should be checked and formaldehyde prepared for use. Also, the specimen jars will be sealed with paraffin. A metal coffee can and a hot plate can be used. Have the coffee can half full of water and chip about one-half a bar of paraffin into the water. The lids of the specimen bottles will be sealed by dipping the lid and a small portion of the bottle in the paraffin-water.

It will be advantageous to use student help in preparing for the future laboratory activities with the chick embryo. BSCS Patterns and Processes is a good reference for the teacher but not much help for the student. BSCS Inquiry into Life (yellow version) is a good technical reference for embryology. Knowledge concerning embryology will enable the teacher to stimulate interest in reading as well as questioning. A most useful reference is A Sourcebook for Biological Science by Morholt, Brandwein, and Joseph, published by Harcourt, Brace, and World.

STUDENT A - 34

FATS

Materials for groups of three:

1. Olive oil
2. White paper towel
3. Test tube
4. Hamburger meat
5. Carbon tetrachloride
6. Eye dropper

This is the final test for the three foods we are considering. Fats are really divided into two groups; the oils which are called polyunsaturated fats and the solids which are called saturated fats. Fat meat is a solid and is called a saturated fat. Olive oil is a liquid and is called a polyunsaturated fat. The only difference in the chemical content is the amount of hydrogen present. By the addition of Hydrogen, unsaturated fats become solids such as cooking fats and margarine. Many people are interested in these two types of fats due to heart conditions.

First, you will find how to test for oils and fats by placing some olive oil on a paper towel. It forms a translucent spot through which light readily passes. If the olive oil contains water, a waiting period will have to be observed for the water to evaporate.

Number the corners of the towel from one to four. In the corner numbere one, place one drop of olive oil. In the corner numbered two, place a drop of water. After placing the drops on the paper towel, lay the towel down on the table, unfolded, and with the numbers up. This is to allow the water to evaporate.

While you are waiting for the water to evaporate you can begin the second test for an unsaturated fat. Place a small piece of hamburger meat in a test tube. Add ten drops of carbon tetrachloride. Remove the hamburge from the test tube with your pencil. Pour a few drops of the remaining liqu on the paper towel in corner number three.

Test peanut butter or crushed peanuts for fats in the same manner, and place the liquid on corner number four.

All of the corners of the paper towel should have a drop of something on them. If fat is present, a translucent spot can be readily seen when you hold the towel up to the light.

3, neg.

Do you have fat in the following places?

TESTS FOR FATS

Corner Number One (Olive oil)	Corner Number Two (Water)	Corner Number Three (Hamburger)	Corner Number Four (Peanut)
Yes No	Yes No	Yes No	Yes No
How do you tell?	How do you tell?	How do you tell?	How do you tell?

Indicate in the table below how you can test a food substance like the white of an egg for the presence of protein, fat, sugar and starch.

FOOD SUBSTANCE	TEST MATERIAL (S)	WHAT YOU DO	RESULT IF PRESENT
Protein			
Fat			
Starch			
Sugar (Karo)			

TEACHER DIRECTION A - 35

NINE DAY EMBRYO

Materials for groups of three:

1. Petri dish
2. Scissors
3. 4 paper towels
4. Forceps
5. Ruler
6. Luke warm water
7. 1 specimen bottle
8. 250 ml beaker

The development of the embryo will be extensive. Most of the body will be formed and many blood vessels will be in evidence. The students will have no trouble in recognizing the blood. A membrane holding waste material, called the alantois can be seen. The amnion, a membrane covering the embryo, will also be readily visible. Do not use these terms as they will only detract from the physical phenomenon being stressed. These membranes can be referred to as the membrane covering the embryo (amnion), and the (alantois) as the membrane forming the septic tank. Another easily observable structure is the tube attached to the stomach of the embryo leading to the yolk of the egg. This is equivalent to the umbilical cord in the human. The point of attachment corresponds to the navel in the human.

TODAY WE OPEN ANOTHER EGG. IT HAS BEEN 9 DAYS SINCE INCUBATION STARTED. THE PROCEDURE WILL BE THE SAME AS BEFORE. REMEMBER TO CRACK THE LARGE END OF THE EGG GENTLY, THEN PEEL THE SHELL AWAY LEAVING ONLY THE MEMBRANE. REMOVE AS MUCH OF THE SHELL AS POSSIBLE BEFORE POURING THE EMBRYO INTO THE WARM WATER IN THE PETRI DISH. AS BEFORE, YOU ARE TO MAKE A DRAWING AND LABEL THE PARTS. (Discussion) WHEN MEASURING THE EMBRYO, MEASURE ALONG THE BACK OF THE EMBRYO. THIS TIME YOU SHOULD BE ABLE TO SEE A MEMBRANE COVERING THE EMBRYO (AMNION) AND A SEPTIC TANK (ALANTOIS). I BET YOU CANNOT FIND THE SEPTIC TANK!

The students are to obtain specimen bottles to preserve the better specimens. It will be obvious that some are not good specimens and should be discarded. Make sure the students label the jars properly giving student names, stage of development, date of opening, and the title "Chicken embryo". A 10% formaldehyde solution (formalin) or alcohol may be used as the preservative. It is recommended that a collection of the embryos at different stages be made and compared to show how the embryo develops.

Pass out A - 35

The students are to begin removing the shell and place the contents of the egg into a petri dish containing luke warm water. It will take most of the period to draw and label the contents of the egg. As the students are working, pass among the groups asking questions.

After completing the activity, make sure the specimen bottles are properly sealed. All spillage should be cleaned well. The contents of the eggs should be discarded.

Teacher direction A - 35 (continued)

If some of the students want to make an acetate, let them draw a picture of their results, then use this acetate to lead a discussion. If the students do not make an acetate, use the prepared acetate. Discuss the embryonic development. Point out that food for the embryo is the albumin and the yolk. Therefore, the quantity of albumin and yolk is reduced. Air is diffused in and out of the egg through the shell and the membrane next to the shell. Also stress the protein, carbohydrate, and fat relation as food.

TEACHER DIRECTION A - 36

CALORIES

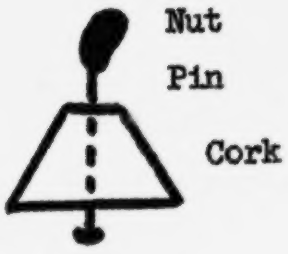
Materials for groups of three:

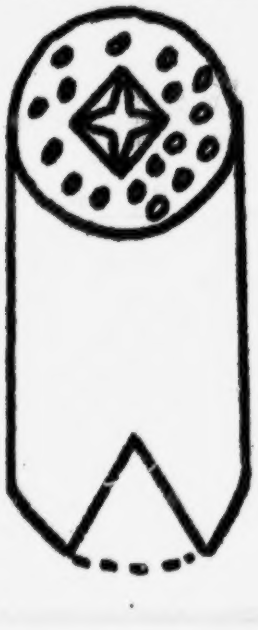
1. Small tin can
2. Cork
3. Pin

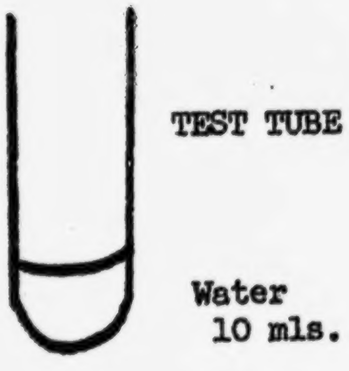
The term calorie is widely used, but few understand its importance. People on diets are generally "calorie counters" and use this as a basis for determining what to eat. This activity will show some of the aspects and measurements of calories. A calorie is the amount of heat required to raise the temperature of one gram of water one degree centigrade. A large Calorie is the amount of heat required to raise the temperature of a liter of water one degree centigrade. Diets are measured in large Calories. An adult needs from 2000 to 3000 Calories per day. Both units are measures of heat energy. 1 C = 1000C. This activity is not very accurate due to heat loss to the atmosphere, but the idea of heat energy and heat content can be shown.

The students should bring in small tin cans the day before you begin this activity. This procedure requires that the students cut an upside-down "v" in the side of the can that has one end cut out. The size of the "v" should be large enough to slide a cork in and out of the can without touching the side. A hole should be cut in the top of the can the size of a test tube. Then small air holes should be randomly made in the top of the can.

The students will measure the calories of heat energy released when small samples of food are burned beneath a test tube containing 10 grams (milliliters) of water.







STUDENT

A - 35

9 DAY EMBRYO

Materials for groups of three:

1. Petri dish
2. Scissors
3. 4 paper towels
4. Forceps
5. Ruler
6. Luke warm water
7. Specimen bottle
8. 250 ml beaker

Your egg has now been in the incubator for nine days. What do you think has happened? Can you predict what you expect to see when you remove the shell? Will the heart be beating faster or slower than in the five day old embryo? Will the amount of yolk and albumin be the same as before, or will it be less? Let's find out by opening the egg as you did in the five day old embryo.

Crack the egg gently on the large end and remove all of the shell you can before breaking the membrane. After removing the shell, cut the membrane with your scissors and pour the contents of the egg into a petri dish that contains luke warm water. The warm water will prevent the rapid cooling of the embryo and prolong the life of the embryo. Remember to work over the paper towels and petri dish at all times.

Make a drawing of the egg and label the parts as you did before. A comparison with your last drawing will be a surprising event. Many changes will be noticeable. Make your drawings and label the parts below.

Select one member of your group to report your observations.

How many times each minute is the heart beating?____________________

Is it beating slower or faster than the five day old embryo?______________

If you cannot see the heart, is there any way you can determine the number of heartbeats?________________ How?

Measure the embryo. How long is it?____________________

Are the eyes well formed?________________________

Describe what you see.

Can you recognize any parts other than the eyes and heart forming? If you do not know what some of the parts are, ask your instructor for a reference book. List the parts below.

1. Is the embryo alive?____________________ How can you tell?

2. Record the following information:
    a. Temperature in the incubator____________________
    b. Number of eggs opened in your group______________
    c. Date eggs were opened________________________
    d. Do you think the eggs are developing as they should?____________
       How can you tell?

NOTE: Bring a small tin can tomorrow.

Teacher direction A - 36 (continued)

A prepared acetate is useful in demonstrating the procedure. This activity will only be concerned with the preparation of the can to act as a calorimeter. BSCS Patterns and Processes is very good reference for students as well as teachers. The can must have air holes at the top or burning of the nuts will not be complete. The triangle at the bottom serves two purposes, to allow an air draft and ease of inserting the cork and burning nut. If the nut does not burn until charred, it is an indication that the air draft is not sufficient.

WE HAVE TALKED AT LENGTH CONCERNING HEAT AND FOOD. THE HEAT OF THE BODY AND THE CHEMICAL REACTIONS THAT TAKE PLACE ARE VITAL IN MAINTAINING LIFE. SCIENTISTS USE A TERM TO EXPLAIN THE FOOD AND HEAT RELATIONSHIP. IT IS CALLED A CALORIE. HOW MANY OF YOU HAVE HEARD THE WORD CALORIE? The students should have heard of low calorie food like Metrecal, Sego, etc. Low calorie bottled drinks are also on the market such as Tab, Fresca, etc. Alcoholic beverages are high in calories. HOW DO SCIENTISTS DETERMINE HOW MANY CALORIES ARE IN DIFFERENT KINDS OF FOODS? Do not expect students to know the answer. Heat energy is the key concept to be concerned with regarding calories. SCIENTISTS DEFINE A CALORIE AS THE AMOUNT OF HEAT REQUIRED TO RAISE THE TEMPERATURE OF ONE GRAM OF WATER ONE DEGREE CENTIGRADE. THESE CALORIE UNITS ARE JUST 1/1000 THE SIZE OF THE FOOD CALORIES USED IN MEASURING HUMAN DIETS. Discussion. One gram of water occupies a volume of one milliliter. HOW WOULD YOU MEASURE OR "COUNT" CALORIES? Discussion. WHAT MATERIALS WOULD YOU NEED TO CARRY OUT THIS EXPERIMENT? Thermometer, test tube, heat emitted from the material in question, and water. OUR NEXT ACTIVITY IS A WAY TO MEASURE CALORIES. WE ARE GOING TO USE TIN CANS, TEST TUBES AND CORKS TO MEASURE THE CALORIES IN A PECAN AND A PEANUT.

Pass out A - 36.

THIS ACTIVITY IS DIVIDED INTO TWO PARTS: PREPARING THE CAN TO BE USED AS A CALORIMETER, AND THEN ACTUALLY DETERMINING THE CALORIES BY RECORDING TEMPERATURE CHANGES IN WATER. IT IS IMPORTANT THAT WE FOLLOW DIRECTIONS ACCURATELY.

Place the prepared acetate on the overhead projector. It will be important to explain each step to the students. The preparation of the can is required to prevent excessive loss of heat. A needle is pushed through a cork with the point extending above the top of the cork as shown on the acetate. A small piece of a nut, approximately 1/4 of 1/2 of the meat of the nut, is placed on the needle point. The nut is to be ignited with a match and placed under the can through the "v" shaped opening. The hole cut in the top of the can should be the size of the test tube. A good way to make this opening is to cut an "x" in the top, then push the test tube through the opening until it is about 1/4 inch above the nut on the cork.

Teacher direction A - 36 (continued)

The steps to follow are:
1. Cut out one end of the can.
2. Cut a "v" out of the side of the can large enough for the cork and nut to pass through.
3. Push a pin or needle through a cork.
4. Cut an "x" in top of the can and insert the test tube.
5. Punch several holes at random in top of the can with a sharp object.

Leave the prepared acetate on the overhead projector while the students prepare their cans. Explain the terms calorimeter and milliliter but do not go into great detail. An understanding will be obtained through the use of the calorimeter and the graduated cylinder. Check the preparation of each can.

After completion of the cans, store them for the next day.

TEACHER DIRECTION A - 37

CALORIE COUNTING

Materials for groups of three:
1. Calorimeter and cork
2. 1/2 pecan
3. 1/2 peanut
4. Thermometer
5. Matches
6. Test tube
7. Graduated cylinder

TODAY WE WILL DETERMINE THE CALORIES IN A PEANUT AND IN A PECAN. REMEMBER THAT A CALORIE IS THE AMOUNT OF HEAT REQUIRED TO RAISE THE TEMPERATURE OF ONE GRAM OF WATER ONE DEGREE CENTIGRADE. WE SHALL MEASURE THE HEAT ENERGY IN SMALL CALORIES. IT WOULD TAKE 1,000 OF THESE CALORIES TO EQUAL ONE CALORIE USED IN PLANNING HUMAN DIETS. READ THE DIRECTIONS CAREFULLY. BEFORE YOU BEGIN, LET'S CONSIDER SOME OF THE IMPORTANT ASPECTS OF THIS ACTIVITY. THE STEPS TO FOLLOW ARE:

1. MAKE SURE YOU HAVE YOUR CAN AND THE CORK YOU ASSEMBLED YESTERDAY.
2. MAKE SURE YOUR TEST TUBE IS 1/2 INCH ABOVE THE POINT OF THE PIN.
3. MAKE SURE THE NUT IS ATTACHED TO THE POINT OF THE PIN SECURELY BEFORE IGNITING.
4. RECORD THE TEMPERATURE OF THE WATER BEFORE IGNITING THE NUT.
5. MEASURE TEN MILLILITERS OF WATER AND POUR IT INTO THE TEST TUBE BEFORE TAKING THE TEMPERATURE OF THE WATER.

YOUR ACTIVITY DIRECTIONS GIVE YOU STEP-BY-STEP DIRECTIONS. FOLLOW THEM VERY CLOSELY AND RECORD THE DATA REQUESTED.

Pass out A - 37.

After completion of the activity reassemble for a class discussion.

STUDENT A - 36

CALORIES

Materials for groups of three:

1. Small tin can
2. 1 cork
3. 1 straight pin or needle

Your tin can will serve a very good purpose in determining the amount of calories in a peanut and a pecan. Before you can determine the calories you must prepare the can. In this activity you are to prepare the can to be a calorimeter and then determine the calories in the next experiment.

A prepared acetate will give you a diagram to go by. Follow directions very closely and do not get cut by the sharp edges.

It is important that you plan exactly what you are going to do in this activity. You are trying to find out how much heat energy is given off by a pecan and a peanut when it is burned. The tin can will help trap this heat energy and the water to be placed in the test tube will absorb the heat. The absorbed heat then can be measured by a thermometer. It will be important to ignite the nuts with a match then very quickly push the nut in the can.

Questions of importance are:

1. Is the "v" cut in the bottom of the can large enough for the cork to pass through easily by sliding the cork?
2. Is the bottom cut out of the can?
3. Does the test tube fit tightly into the top of the can?
4. Is the test tube about 1/2 inch above the point of the needle?
5. Are there enough holes in the top of the can?
6. How much is 10 ml of water?

Teacher direction A - 37 (continued)

At this point it will be necessary to attempt to tie all of the material together. The following activities will consider digestion and it is important that a good understanding of heat, proteins, fats, and carbohydrates be exhibited by the students. The immediate problem of discussing calories should lead into the understanding of digestion. The chemical reactions of biology are the sources of heat and are therefore directly related to the chemical substances of proteins, carbohydrates, and fats.

Use the prepared acetate and discuss the findings. There will be variations in the results. This will be obvious in the discussion. Explain these variations through class discussion of the procedure. If an extremely high reading is reported, it will probably be due to the cork catching on fire or reading the wrong scale on the thermometer. Some of the reasons for the wide variation in results will be:

1. Loss of heat through the tin can.
2. Loss of heat while lighting the nut before it is placed in the can.
3. Inaccuracy in reading the thermometer (must be centigrade)
4. Inaccuracy in measuring the quantity of water.
5. Cork catching on fire.
6. The number of holes in the can permits the heat to escape too rapidly.
7. Nut going out before completely burning.
8. Not using same size piece of nut.

After discussing these aspects, discuss the idea that the body develops heat energy by chemical processes and therefore maintains its temperature of 98.6°F which is most favorable for maintaining the proper chemical activity for life.

TEACHER DIRECTION A - 38

BODY MOVEMENT AND TEMPERATURE

Materials for groups of three:

1. Ice
2. Large beaker, 600 ml
3. Thermometer

This activity should demonstrate the relation of very cold water and the functions of the body. It is obvious that placing one's hand in cold water causes something to happen that is uncomfortable. The heat energy transfer will be from the body into the foreign medium if the medium is colder than the body. This activity should demonstrate this idea.

WE HAVE DISCUSSED AND INVESTIGATED HEAT AND HOW TO DETERMINE CALORIES. LET'S NOW LOOK AT WHAT HAPPENS WHEN WE ARE PLACED IN A VERY COLD SITUATION. WHAT WOULD YOUR BODY DO TO MAINTAIN ITS NORMAL TEMPERATURE? React in ways that tend to conserve its heat energy. List all responses on the overhead projector. LET'S FIND OUT WHAT YOUR HAND WOULD DO IF PLACED IN A FREEZING CONDITION. BY THE WAY, AT WHAT TEMPERATURE DOES WATER FREEZE?

CALORIE COUNTING

Materials for groups of three:

1. Calorimeter and cork
2. 1/2 pecan
3. 1/2 peanut
4. Thermometer
5. Matches
6. Test tube
7. Graduated cylinder

Remember that a calorie is the amount of heat energy required to raise the temperature of one gram of water one degree centigrade.

Follow the directions very closely. After each step, record the data in the table if there is a space provided to write it.

1. Place the calorimeter upright, insert the test tube and adjust it so that the tube is 1/2 inch above the point of the pin.
2. Obtain 10 ml of water and pour it into the test tube.
3. Break the pecan into four pieces and place one piece on the needle.
4. Record the temperature of the water in the test tube.
5. Ignite the nut and immediately push it through the opening in the can directly under the test tube.
6. Record the temperature of the water immediately when the fire goes out.

Repeat these same steps for determining the calories in a peanut. Try to obtain a piece of the peanut the same size as the piece of pecan used the first time. Record the data in the table on the next page.

STUDENT
Page 2

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Data Sheet

PECAN		PEANUT	
Temperature of water before lighting the pecan	________°C	Temperature of water before lighting the peanut	________°C
Temperature of water after the pecan quits burning	________°C	Temperature of water after the peanut quits burning	________°C
Difference in temp.	________°C	Difference in temp.	________°C

Divide the difference in temperature by 10 because there are 10 ml water.

PECAN: $\frac{\text{Difference in temperature}}{10}$ = ____________calories

PEANUT: $\frac{\text{Difference in temperature}}{10}$ = ____________calories

Which nut has the most calories? ________________________

How can you tell?

Did the water boil?__________ If it did, what effect would this have on your results?

Did the cork catch on fire?____________ Would this affect your results?____

How would this affect your results?

List several ways that you can make this activity more accurate.

Teacher direction A - 38 (continued)

Pass out A - 38.

Using a prepared acetate, discuss the procedure and instruct the students to begin work immediately.

The students are to place ice in a beaker half filled with water. The ice is to be placed in the beaker and stirred with a thermometer until the temperature reaches about 32°F, then remove the ice. The first activity is to submerge a hand without moving it for two minutes. At 30 second intervals, students are to record the temperature of the water. Starting with the same amount of water at 32°F, the second activity requires the students to move their hands by opening and closing their fingers for two minutes while in the water, then record the temperature of the water as before. It will be obvious that more heat exchange will take place when moving the hand.

The data sheet asks that each member determine the heat exchange, then determine the average for their group. The students may need some help in calculating the average.

After completing the activity, reassemble for class discussion. Using the prepared acetate, calculate a class average and point out the differences in temperature variation with regard to movement. It will also be a good idea to compare hand sizes and temperature differences.

Many other class activities could be developed using different materials as well as differing medias. If time permits, students may devise other experiments and try them out.

TEACHER DIRECTION A - 39

SIXTEEN DAY EMBRYO

Materials for groups of three:

1. Petri dish
2. Scissors
3. Forceps
4. 4 paper towels
5. Ruler
6. Luke warm water
7. Specimen bottles

The methods are the same as used for the five-day embryo. The same prepared acetate can be used. The embryo will show a great deal of development. The students should be able to see that the embryo is looking more like a chicken. Directions should not be extensive. Much time can be used in individual attention.

Pass out A - 39.

Reassemble for discussion after the completion of the activity. This is an excellent time for testing understanding. Do not test until understandi is accomplished.

STUDENT A - 38

BODY MOVEMENT AND TEMPERATURE

Materials for groups of three:

1. Ice
2. Large beaker (600 ml)
3. Thermometer

The human body is really a magnificent machine, but it must run at a certain temperature to operate properly. As we have already found out, the chemical reactions give us the necessary heat energy, but how does the body 'know' to speed up or slow down the development of heat energy. Many important questions concerning this very important question are now being studied in research laboratories. Many of the answers still are not known. Scientists must take small parts of a larger question and study them individually. Later they put all of the smaller answers together in order to answer the larger question. In this activity we will only look at two small parts of the heat energy question. Let's find out what the hand does when placed in ice water. Will the hand give off more heat if you move your hand, or will it give off more heat if your hand is not moved? You probably know the answer, but can you demonstrate it?

Fill a beaker half full of water and place some ice in the beaker. Gently stir the water and ice until the temperature reaches about 32°F. Then remove the ice and stick your hand in the ice water for two minutes. Have one of your lab partners record the time. YOU ARE TO KEEP YOUR HAND IN THE WATER FOR TWO MINUTES WITHOUT MOVING IT. Record the data in the table on the next page.

STUDENT NUMBER ONE

Temperature when the hand is first placed in the ice water ________°F

Temperature 2 minutes after the hand is placed in the ice water ________°F

Temperature difference ________°F

STUDENT NUMBER TWO

Temperature when the hand is first placed in the ice water ________°F

Temperature 2 minutes after the hand is placed in the ice water ________°F

Temperature difference ________°F

STUDENT NUMBER THREE

Temperature when the hand is first placed in the ice water ________°F

Temperature 2 minutes after the hand is placed in the ice water ________°F

Temperature difference ________°F

The data obtained can be more meaningful if you find an average. So add all of the temperature differences and find out the average by dividing the total differences by three.

The average temperature differences is ________°F.

Remember that this is the temperature change for no movement of the hands. Next find out what the average temperature difference will be when you move your hand. Each student is to move his hand by opening and closing his fingers only.

SIXTEEN DAY EMBRYO

Materials for groups of three:

1. Petri dish
2. Scissors
3. Forceps
4. 4 paper towels
5. Ruler
6. Luke warm water
7. Specimen bottles

Your egg has now been in the incubator for 16 days. What do you think has happened? Could you predict what you expect to see when you remove the shell? Will the heart be beating faster or slower? Will the amount of yolk and albumin be the same as before? Let's find out by opening the egg as before and observe the embryo.

Crack the egg gently on the large end and remove all of the shell you can before breaking the membrane. After removing the shell, cut the membrane with your scissors and pour the contents into a petri dish containing luke warm water. The warm water will prevent rapid cooling of the embryo and prolong its life. Remember to work over paper towels and the petri dish at all times.

Make a drawing of the egg and label the parts as you did before. A comparison with your last drawing will be a surprising event. Make your drawing and label the parts below.

STUDENT
Page 2

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Measure the embryo. How long is it?____________________

Are the eyes well formed?______________________________

Can you see any feathers?____________What color are they?__________________

Can you predict what color the chicken will be?____________________

How can you make this prediction?______________________________________

Write a short paragraph describing what you see.

Is the embryo still alive?_________________ How can you tell?

Record the following information:

1. Temperature of the incubator____________________
2. Number of eggs opened in your group ____________
3. Date eggs are opened (today) __________________
4. Do you think the eggs are developing as they should?______________
   How can you tell?
5. When do you think the chickens will hatch?______________ days

TEACHER DIRECTION A - 40

NINETEEN DAY EMBRYO

Materials for groups of three:

1. Petri dish
2. Scissors
3. Forceps
4. 4 paper towels
5. Ruler
6. Luke warm water
7. Specimen bottle

The development of the chick will almost be completed. The chick will be very well formed and completely fill the shell. Instruct the students to proceed as in the previous activities and follow up the activity with discussions as before.

The eggs, if on schedule, will be hatching in two days. It will be necessary to remove the eggs from the paper holders and place them in a box in the incubator. The hatching chickens will need a place to walk around for several hours after hatching to gain strength and dry out. You and your students will have an extensive amount of preparation and planning to determine how to best handle the newly hatched chicks.

After the chicks have hatched, the incubator should be thoroughly cleaned with a formalin solution and aired out.

Many activities can be performed after hatching, such as observing peck order, eating habits, evidences of imprinting, etc.

TEACHER DIRECTION A - 41

BEGINNING OF DIGESTION

Materials for groups of three:

1. Bread
2. Test tubes (2)
3. Iodine solution
4. Benedict solution
5. Corn starch solution (10%)
6. Alcohol burner

The first stage of digestion begins in the mouth. The chewing process serves two purposes: (1) to expose more surface area of the food to saliva and (2) to aid in swallowing. The first enzyme reaction occurs with the contact of the saliva and the food. There is no need to stress enzymes or even introduce the term, but if mentioned they can be defined as a chemical that aids in digestion. The actual reactivity of enzymes is very important and very complicated. The test will demonstrate that food is changed in the digestive system by chemical reactions and this chemical reaction is supported by mechanical means such as chewing.

WE HAVE TALKED ABOUT THE YOUNG EMBRYO USING PROTEINS, CARBOHYDRATES, AND FATS FOR FOOD. LET'S NOW TAKE A LOOK AT THE WAY DIGESTION BEGINS. WHAT IS THE FIRST THING THAT HAPPENS WHEN A PERSON TAKES A BIG BITE OF SOMETHING? Chewing and introduction of saliva. The students will probably readily think of chewing, but not saliva. If they did not mention saliva, then suggest that a fluid in the mouth covers the food.

STUDENT A - 40

19 DAY EMBRYO

Materials for groups of three:

1. Petri dish	5. Ruler
2. Scissors	6. Luke warm water
3. Forceps	7. Specimen bottle
4. 4 paper towels	

Your egg has been in the incubator for 19 days. What do you think has happened? Predict what you expect to see when you remove the shell? Will the heart be beating faster or slower? Will the amount of yolk and albumin be the same as before? Let's find out by opening the egg as before and observe the embryo.

Crack the egg gently on the large end and remove all of the shell you can before breaking the membrane. After removing the shell, cut the membrane with your scissors and pour the contents into a petri dish containing luke warm water. The warm water will prevent the cooling of the embryo too fast and will prolong the life. Remember to work over paper towels and the petri dish at all times.

Make a drawing of the egg and label the parts. A comparison with your last drawing will be a surprising event. Make your drawing and label the parts below.

Teacher direction A - 41 (continued)

SCIENTISTS HAVE FOUND THAT CHEMICAL REACTIONS BEGIN IN THE MOUTH. IN THIS ACTIVITY YOU WILL FIND OUT WHAT HAPPENS IN THE MOUTH. WE HAVE PREPARED AN UNKNOWN SOLUTION (corn starch) THAT HAS ALREADY BEEN CHEWED UP AND READY TO SWALLOW. I WANT YOU TO FIND OUT WHAT HAPPENS AND TELL THE CLASS WHAT YOUR GROUP FINDS. IT WILL BE VERY IMPORTANT THAT YOU NOT TELL UNTIL WE RETURN TO THE CLASS DISCUSSION AFTER THE ACTIVITY. IF ANOTHER GROUP WANTS TO KNOW WHAT YOU FIND OUT, DO NOT TELL THEM. I WILL GIVE YOU TWO CLUES. FIRST, THE IODINE SOLUTION AND THE BENEDICT SOLUTION WILL BE THE ONLY CHEMICALS I WILL GIVE YOU, SO YOU KNOW YOU MUST TEST FOR SUGAR OR STARCH. SECONDLY, THE SALIVA MUST BE FURNISHED BY A MACHINE. Have the students begin as soon as possible after the clues. Attempt to be somewhat evasive in order to have the students approach the problem independently. Be very careful not to ignore the students to the extent of preventing them getting started.

Pass out A - 41.

After the students complete the activity, reassemble for a class discussion. Using the overhead projector, develop the first stages of instruction. The corn starch is rich in starch and iodine will readily prove this. The students can spit into a test tube containing the starch solution and warm it a few minutes. Sugar will be formed, thus showing that starch is changed into sugar in the mouth and is therefore the first chemical reaction of digestion. By discussion have the students to develop the following formula. If necessary, write the formula on an acetate for their discussion.

Starch + chewing + saliva = Sugar + saliva

Some of the saliva is of course swallowed, but the remaining saliva can attack the next bite of food. The bread may also be used if the students wish to pursue the activity further.

STUDENT A - 41

BEGINNING OF DIGESTION

Materials for groups of three:

1. 2 test tubes
2. Benedict's solution
3. Iodine solution
4. Bread
5. Unknown solution
6. Alcohol burner

When you eat, a very complicated process begins. Your strong teeth tear and mash the food into small pieces that makes the food easy to swallow. Other things also take place. Your mouth contains saliva that completely bathes the food as you chew. Many years ago it was found that saliva is a chemical substance that acts in digestion. You are to find out what this important chemical reaction is between food and saliva. Your instructor will give you an unknown solution and you are to find out what happens when it comes into contact with saliva. Do not drink this solution, but use test tubes to test the reaction.

The activity will be in two parts. The first part is to determine if the solution is a starch or sugar solution. The second part is to determine what happens to the solution after you spit into the solution.

PART A

Fill both test tubes about half full of the unknown solution. Label the test tubes number 1 and 2.

Test the material in test tube number 1 for starch with iodine.

IS STARCH PRESENT?_______________

Test the material in test tube number 2 for sugar.

IS SUGAR PRESENT?_______________

What is the unknown solution, starch or sugar?_____________________________

PART B

After washing the test tubes very thoroughly, refill them about half full of the unknown solution. Label the test tubes 1 and 2. To both test tubes add an abundant amount of saliva and shake the test tubes vigorously for five minutes to mix the solutions very well.

Test the material in tube number 1 for starch.

IS STARCH PRESENT?________________

Test the material in tube number 2 for sugar.

IS SUGAR PRESENT?________________

The unknown solution has possibly changed. If so, what change took place?

Write a short paragraph explaining what you have observed.

Try to write a formula showing what has happened.

Appendix 1

SUGGESTED CALENDAR FOR STUDY OF CHICK DEVELOPMENT *

Mon.	Tues.	Wed.	Thurs.	Fri.
Introduction of Topic p. 106	Demonstration Activity p. 107 (evaporation)	Continue Nature of Foods p. 107	Discussion of Material EGGS PLACED IN INCUBATOR TODAY! p. 108	A - 30 OBSERVE UNFERTILE EGG p. 111
OPEN AND OBSERVE 5 DAY EMBRYO A - 31 p. 114	Proteins A - 32 p. 117	Carbohydrates A - 33 p. 120	Fats A - 34 p. 122	OPEN AND OBSERVE 9 EMBRYO A - 35 p. 126
Calories A - 36 p. 130	Calories A - 36 p. 130	Calorie Counting A - 37 p. 132	Body Movement and Temperature A - 38 p. 135	OPEN AND OBSERVE 16 DAY EM A - 39 p. 137
OPEN AND OBSERVE 19 DAY EMBRYO A - 40 p. 140	Digestion A - 41 p. 142			

* A 21 consecutive day period without holidays or interruptions must be had in order for development of the eggs to fit the school calendar.

Appendix 2

MATERIALS AND APPARATUS

A. Materials for Small Group Laboratory Work

Materials	For groups of three	For class of thirty
Beaker, 250 ml	2	20
Beaker, 500 ml	2	20
Burner, alcohol	1	20
Burner, gas	1	20
Can, 1 gallon (Rectangular)	1	20
Cork, No. 4	1	20
1 inch dowling, 36 in. (2 holes, 9 in. and 18 in.)	1	10
1/2 inch dowling, 12"	1	10
Eye dropper pipette	1	10
Fishing sinkers, 8 oz.	1	10
Fishing sinkers, 4 oz.	1	10
Flask, 500 ml	1	10
Graduated cylinder, 100 ml	1	10
Jar, specimen	4	40
Hard wood, small block	1	10
Monofilament line, 24 in.	1	10
Paper towel	1	10
Petri dish	1	10
Ring stand	1	10
Rubber Band	2	20
Rubber Stopper, No. 4	1	10
Ruler, 12"	1	10
Test tube holder	1	10
Test tubes	4	40
Thermometers, F° and C°	1	10
Tongs	1	10
Washers, flat, 4 oz.	10	100
Washers, flat, 45/pound	10	100
Wire hooks, weight hangers	2	20

Materials and Apparatus (Continued)

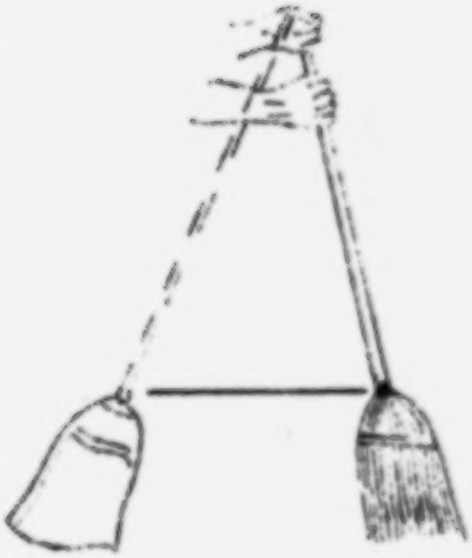
B. Materials for Class

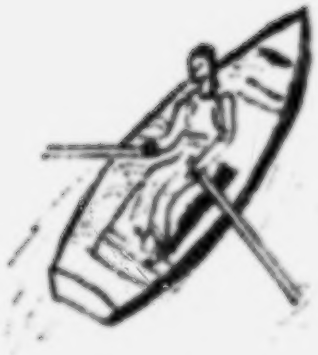
Material	Quantity
Acetates, Clear	1 Box, 100/Box 20
Bathroom Scales	1
Graduated Cylinder, 500 ml.	1
Harcourt, Brace and World Classroom Laboratory No. 6 (will supply 18 students)	2
Hotplate	1
Incubator	1
Optical Illusions (3M)	1 set
Overhead projector and screen	1
Thermo-duplicator	1
Thermo-spirit acetates (3M-127)	1 Box, 100/Box
Thermo-spirit Masters	1 Box, 100/Box

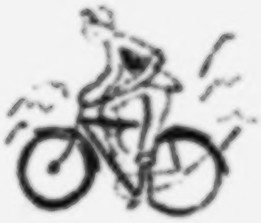
C. Reagents for Class

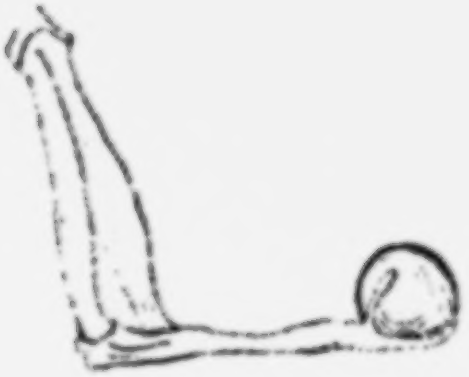
Name	Quantity
Alcohol, methyl or ethyl	2 gal.
Carbon tetrachloride	1 pint
Benedict's Solution	4 oz.
Dry ice	2 lb.
Ether, Petroleum	1 pint
Formaldehyde, 40% by Vol.	1 gal.
Ice, chipped	15 lbs.
Iodine Solution	8 oz.
Karo Syrup (white)	1 bottle
Nitric Acid, Technical grade	1 lb.
Olive Oil	4 oz.
Parafin, Wax	1 lb.
Starch, Solution	1 bottle

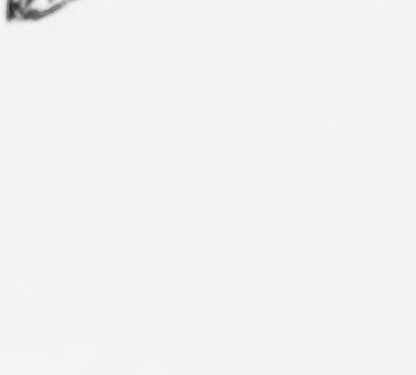
APPENDICES

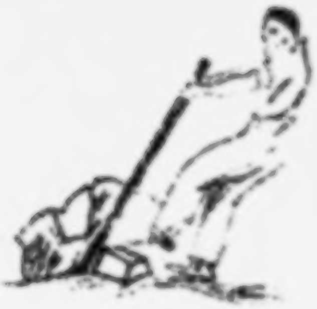


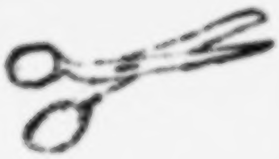


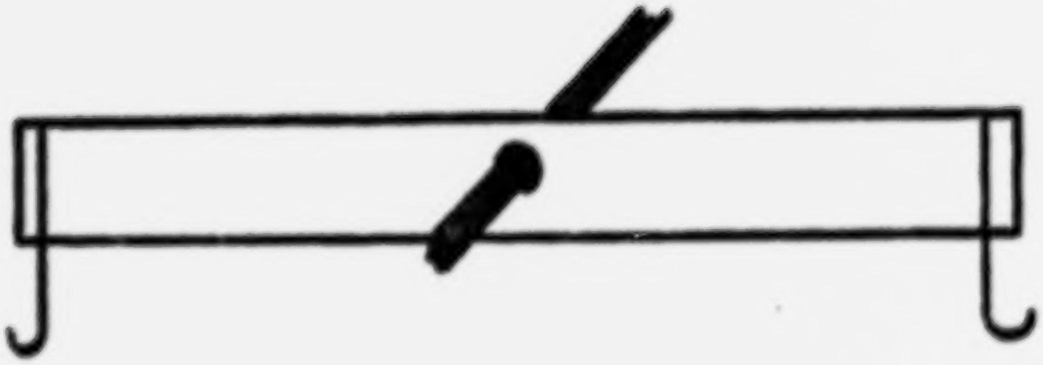












1 3

A 3

DATA ON SHOES

GROUP NUMBER	HEAVIEST SHOES	LIGHTEST SHOES

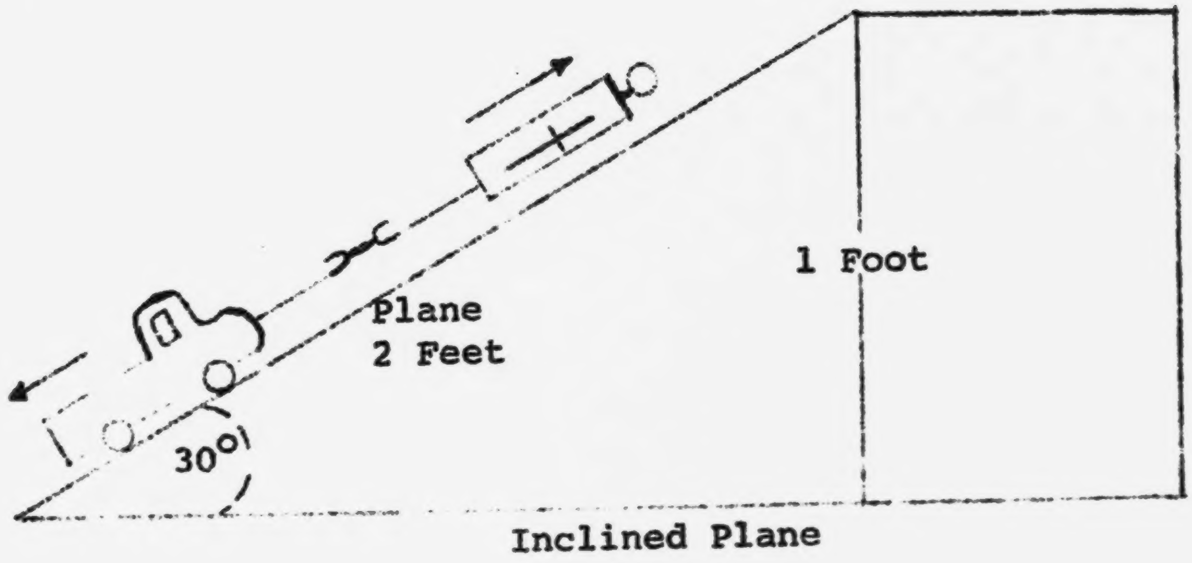
LEFT SIDE		RIGHT SIDE		
Number of Weights	Position	Number of Weights	Position	
2	6	2		
2	6	1		
3	4	2		
3	5	1		
3	3	1		
2	6	4		
4	4	2		
1	12	3		

MOMENTS OF FORCE

Number	Left Side			Right Side		
	Weight	Position	Moment	Weight	Position	Moment
1	1 xxx	8 xxx	00	1 1	3 5	
2	1 xxx	10 xxx	00	1 1	7 3	
3	1 1	4 8		1 xxx	12 xxx	00
4	1 xxx	14 xxx	00	1 1	6	
5	1 xxx	13 xxx	00	1 1	5	
6	1 1	3 8		1 xxx	xxx	00
7	1 1	5 9		1 xxx	xxx	00
8	1 xxx	xxx	00	1 1	3 6	

WORK =

Object	Distance	Force pounds	Work Foot - Pounds
1 Book	1 Foot		
1 Book	2 Feet		
1 Book	3 Feet		
2 Books	2 Feet		
2 Books	4 Feet		
1 Shoe	2 Feet		
1 Shoe	4 Feet		
1 Chair	1 Foot		


1 Foot
Plane
2 Feet
30°
Inclined Plane

Object	Distance height	Resistance force	Work ft-oz	Length plane	Effort force	Work ft-oz
Truck	1 foot	4 ounces		2 feet		
Truck one weight	1 foot	8 ounces		2 feet		
Truck two weights	1 foot			2 feet		

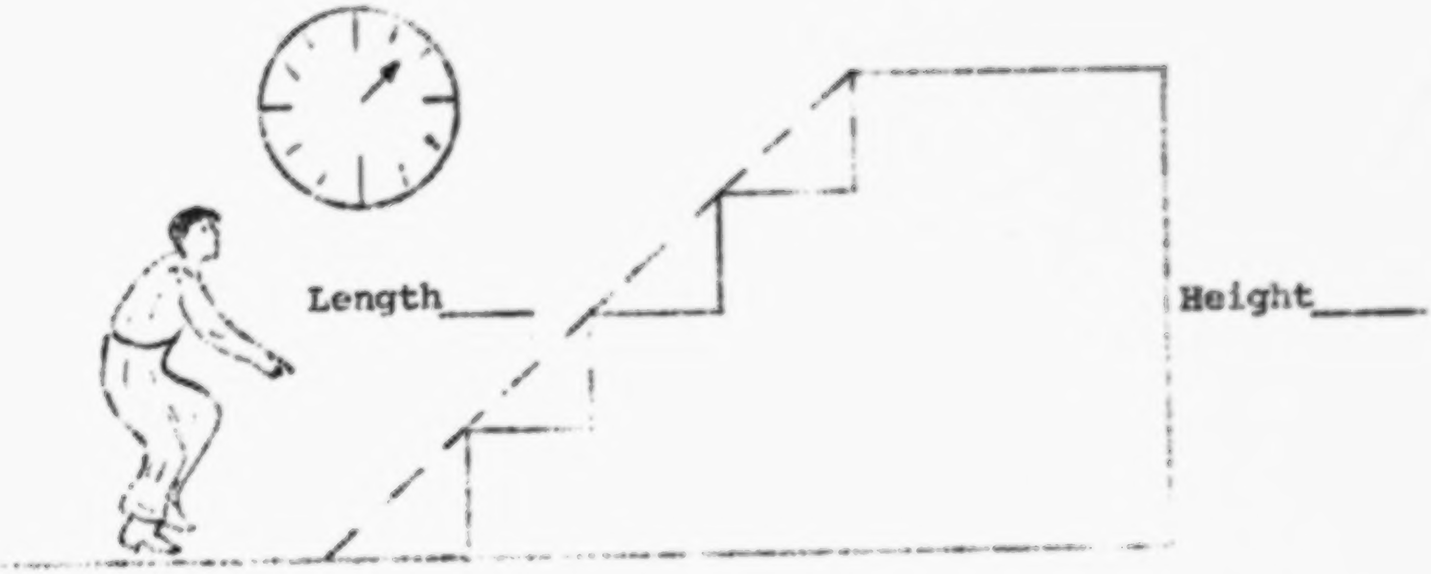
Height of stairs	Resistance weight of runner	Work Foot-pounds

DISTANCE times RESISTANCE = WORK

Work (from above)	Length of Plane (feet)	Effort Force (pound)

WORK Divided by LENGTH = EFFORT FORCE

A 10
A 11

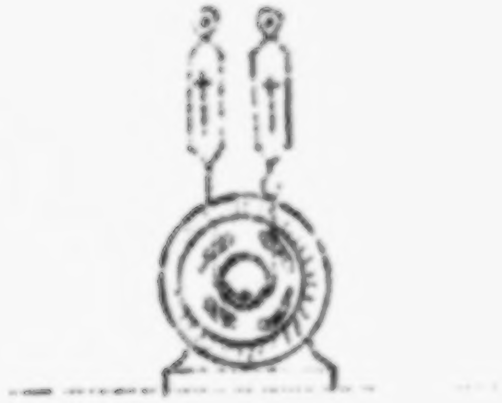


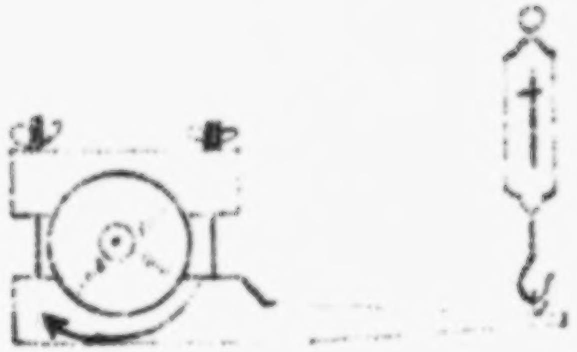
Height of Stairs	Resistance Weight of Runner	Work Foot - Pounds

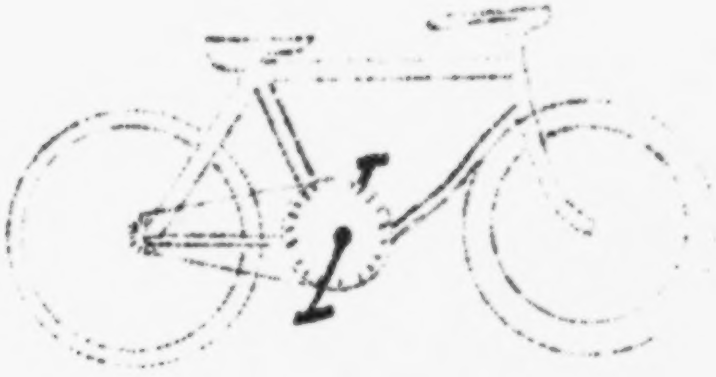
DISTANCE TIMES RESISTANCE = WORK

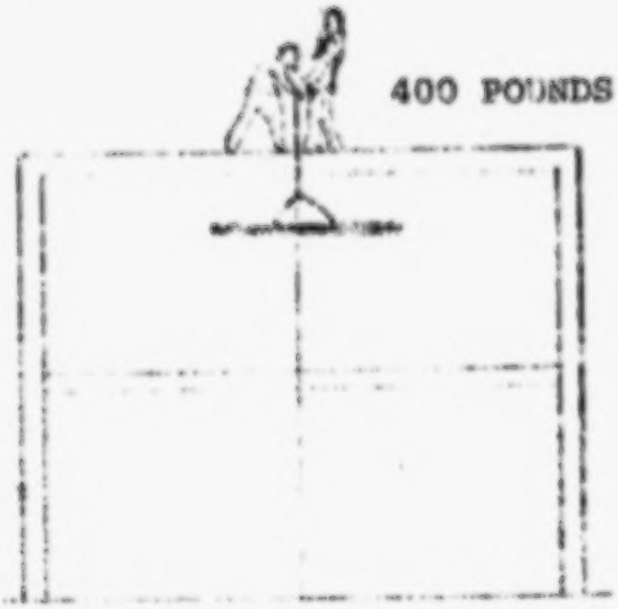
Work from above	Time Seconds	POWER

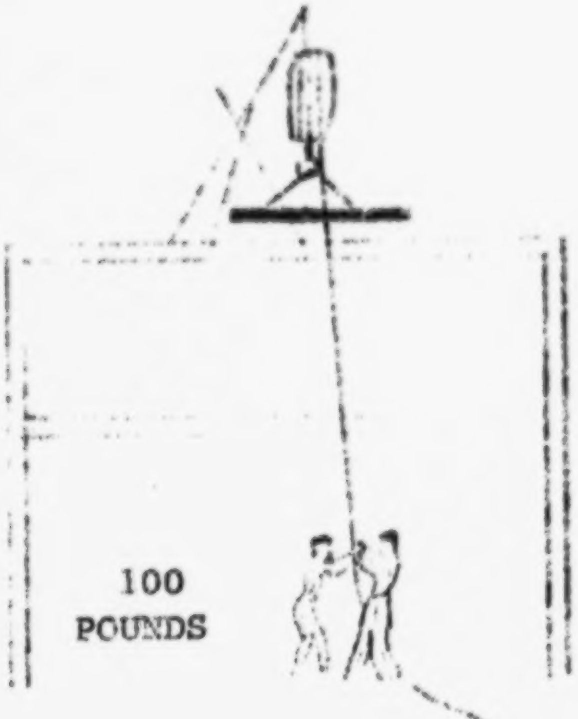
13





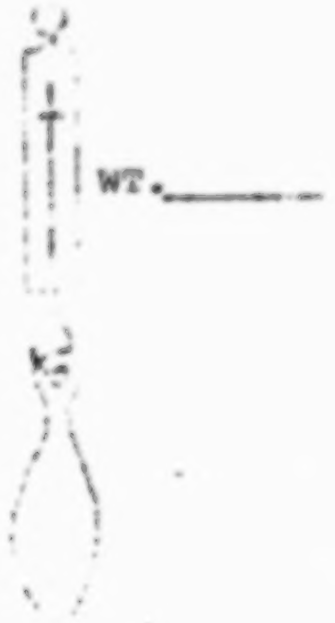



400 POUNDS


100
POUNDS

14

NO. 1



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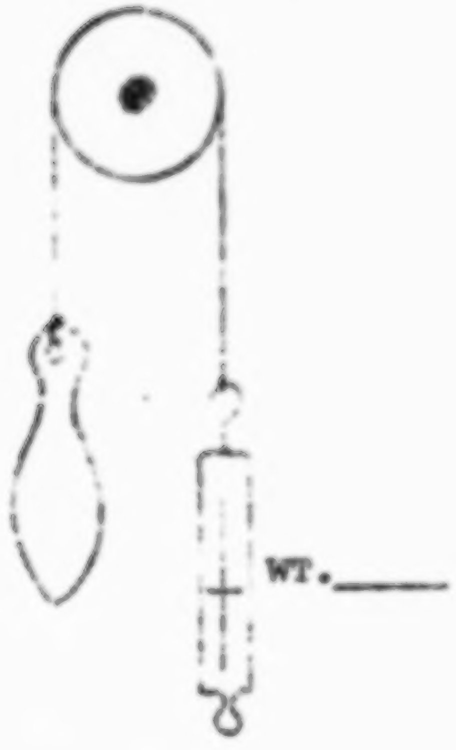

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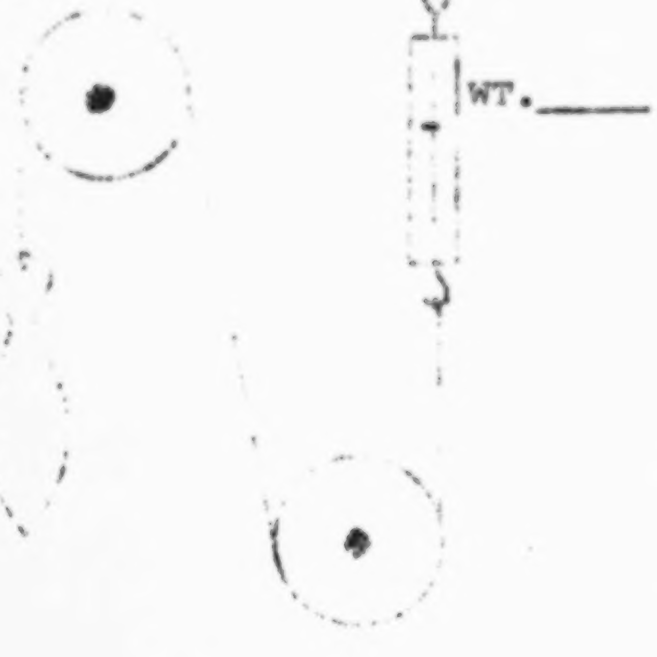

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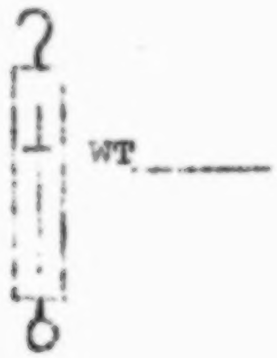
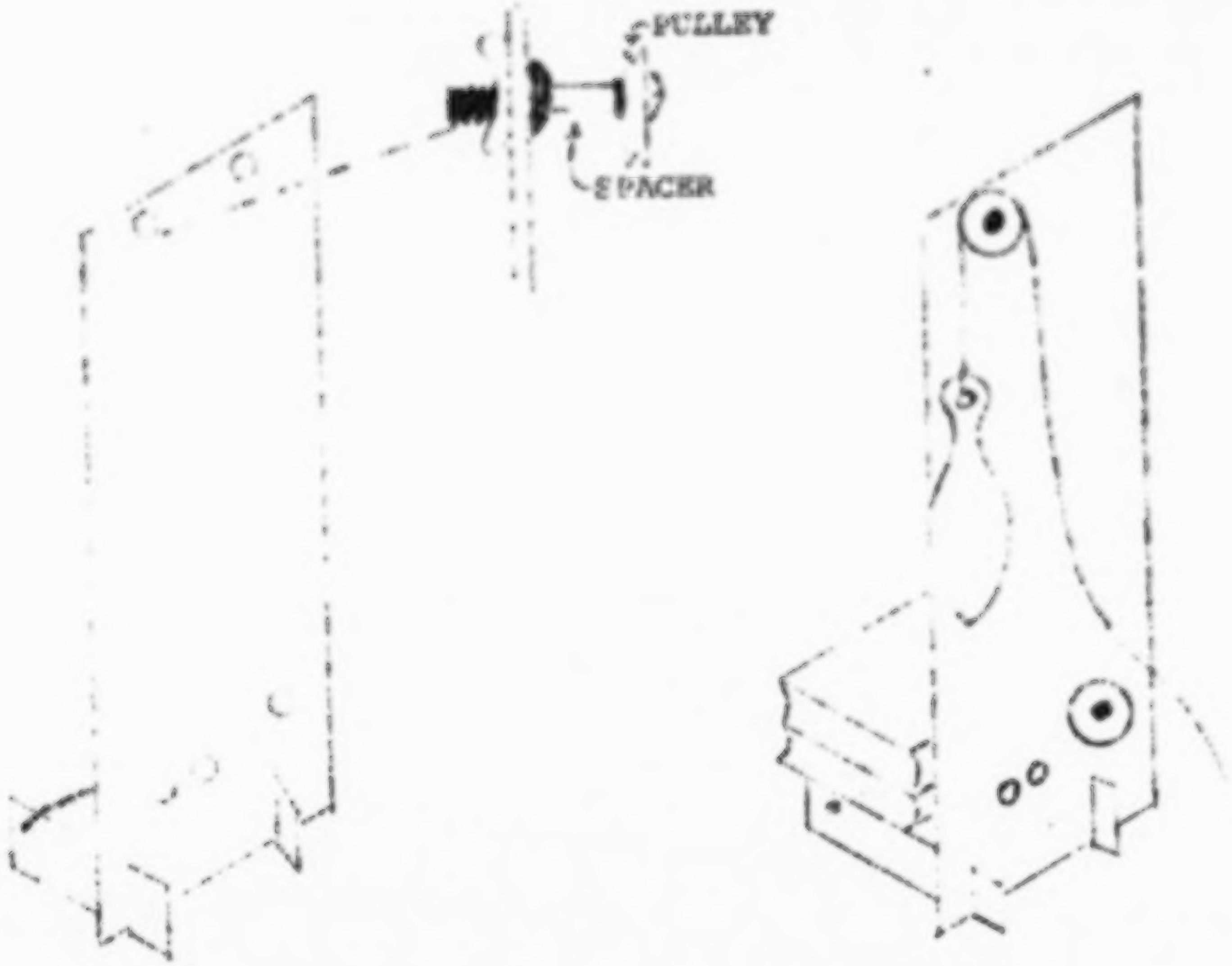
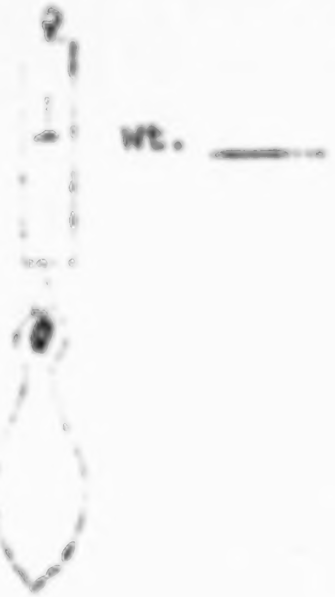


A 14


PULLEY
SPACER

NO. 1



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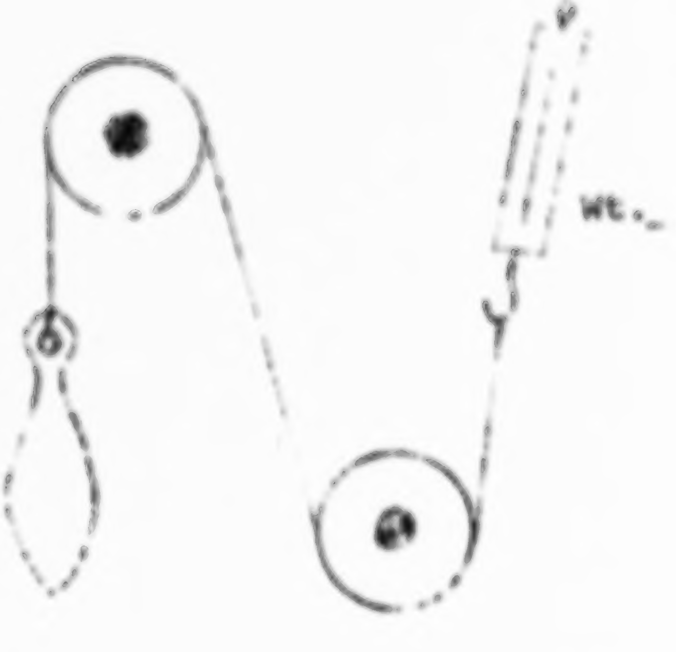

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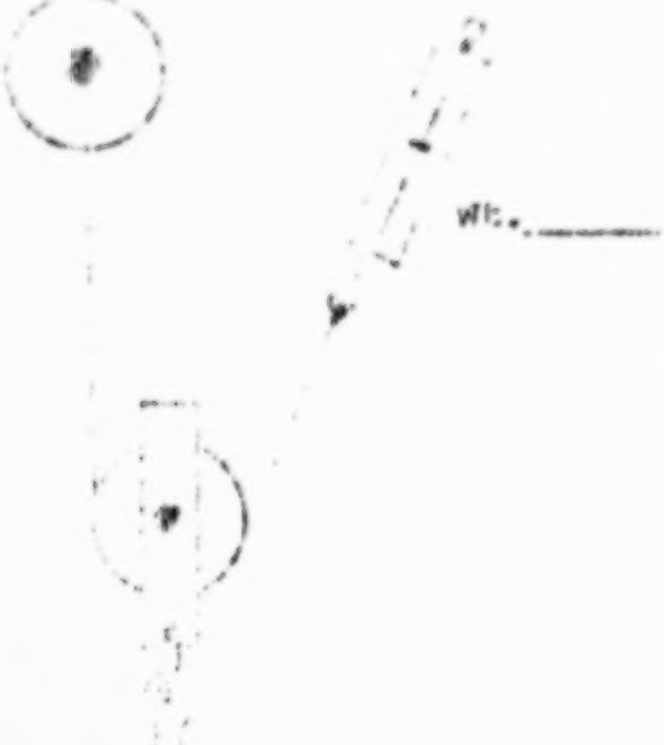

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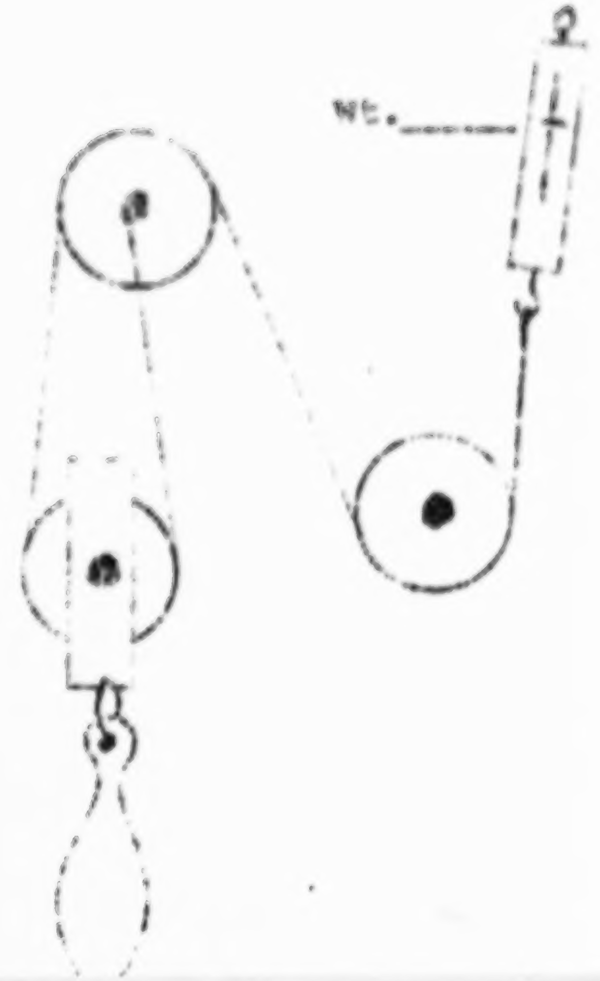
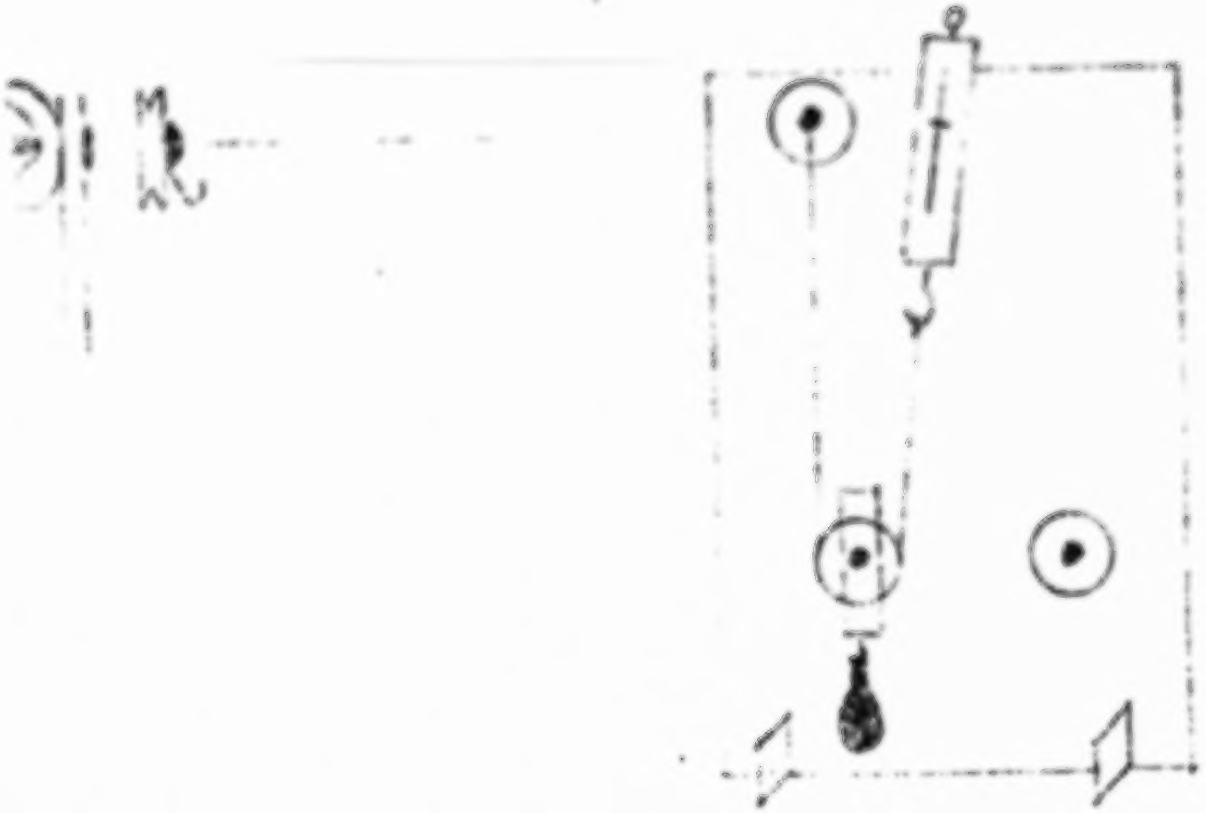
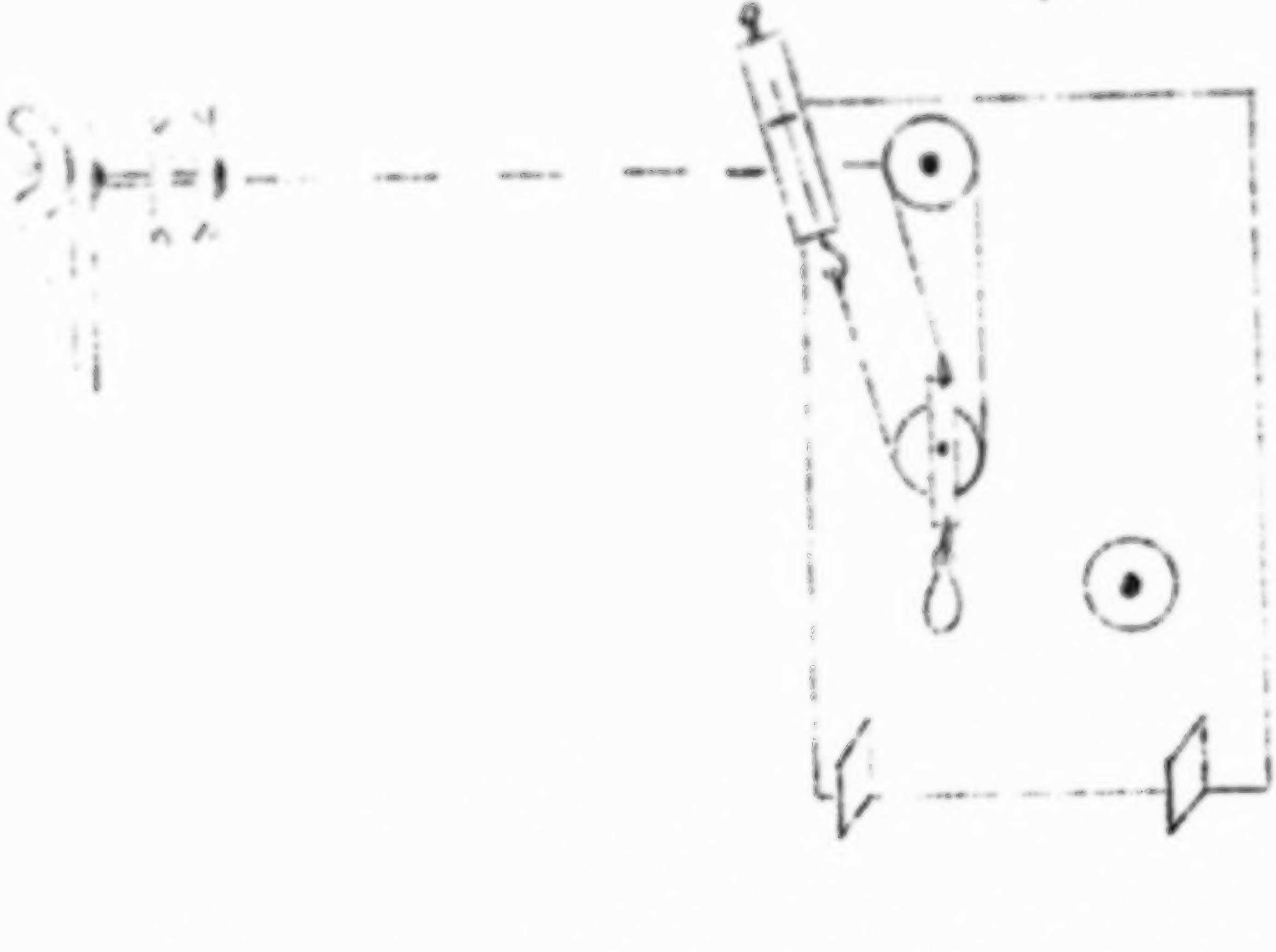


À 15

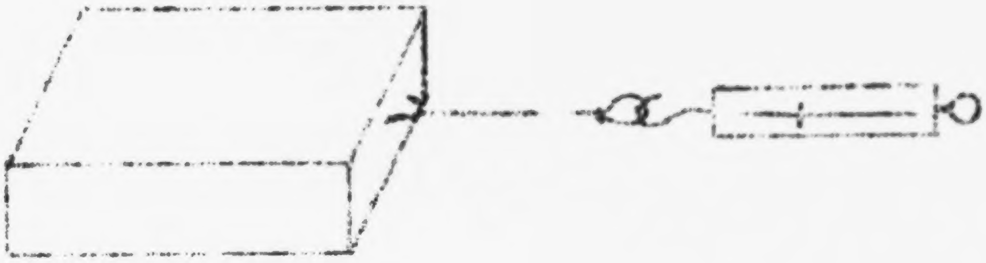


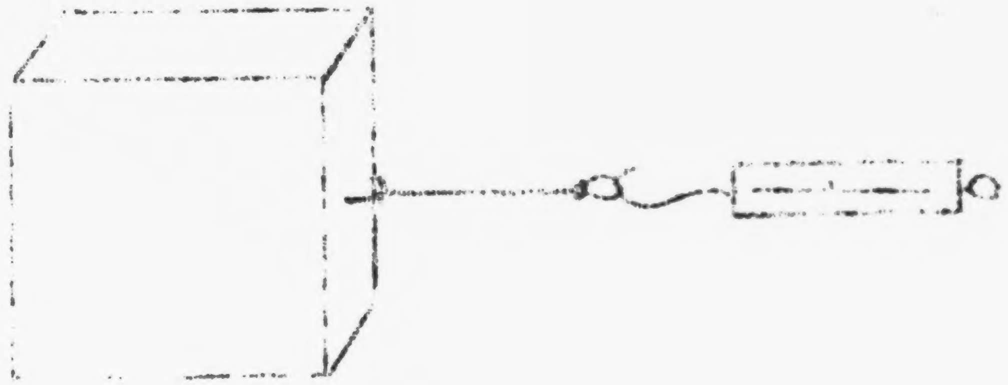


DATA ON FRICTION

Observer number	Force required to start the block moving	Force required to maintain a constant speed	Position of Block	Weight of Block
1			wide side	
			narrow side	
2			wide side	
			narrow side	
3			wide side	
			narrow side	

WEIGHT ____________



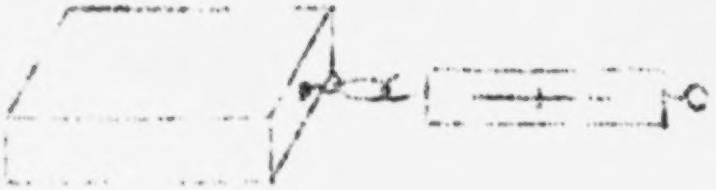


WEIGHT ____________

A 17
A 18

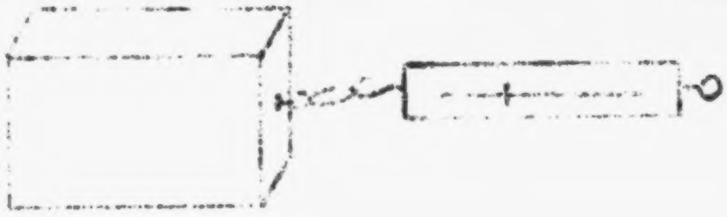
WEIGHT ________

STARTING FORCE________
SLIDING FORCE ________



WEIGHT________

STARTING FORCE________
SLIDING FORCE ________

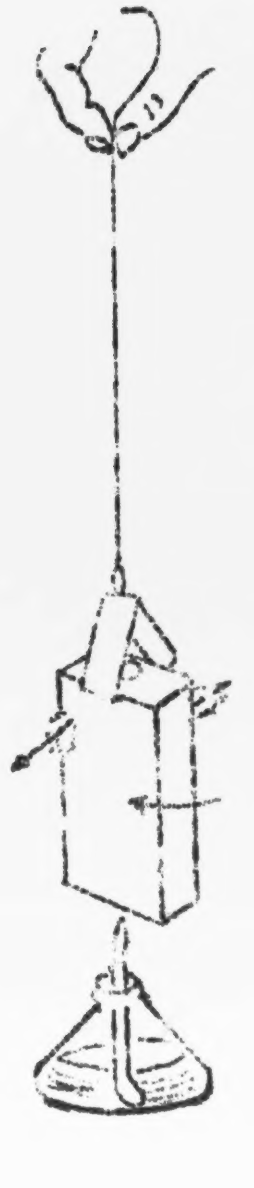


A 19

		FORCE		WHY
Object	Position	Table	Sand	Type of friction
Truck	Rolling			
	Side			
	Rolling and Weight			
Yellow Friction Board	Smooth Side Down			
	Rough Side Down			
	Rough side of yellow board on the rough side of the blue board			

A 23

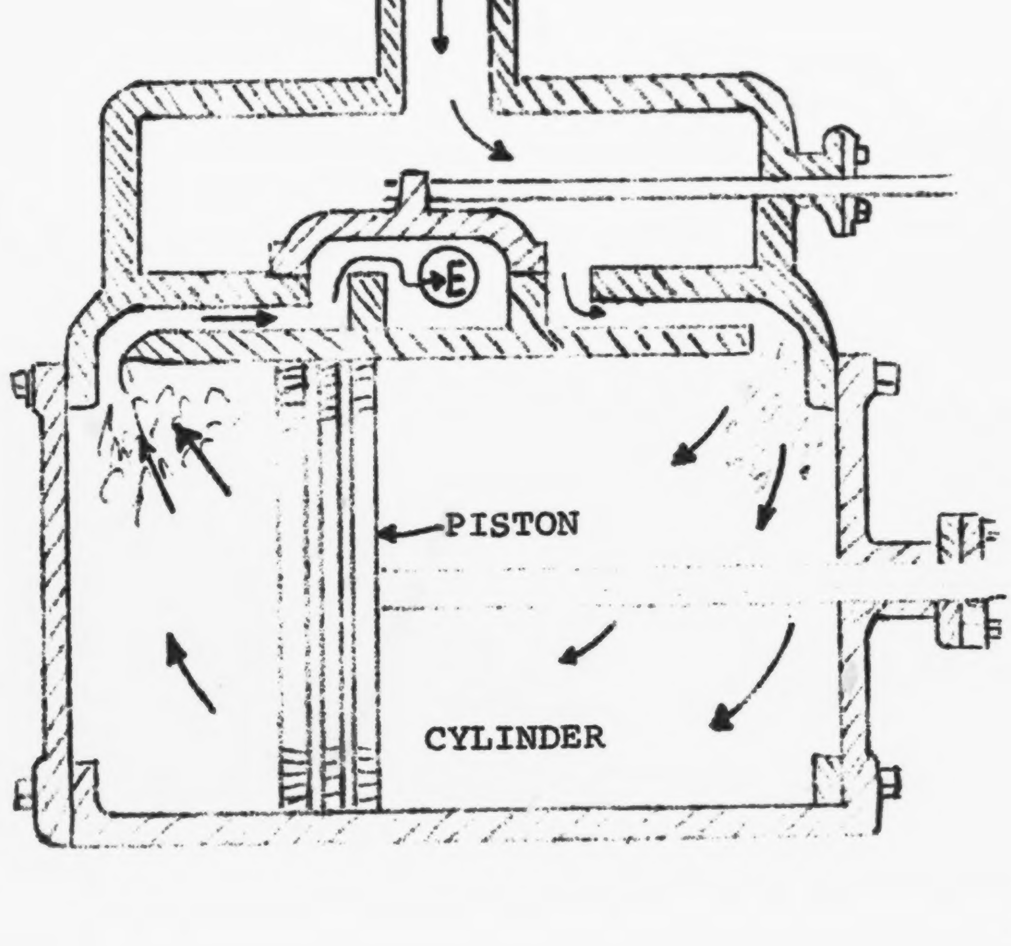
A 24



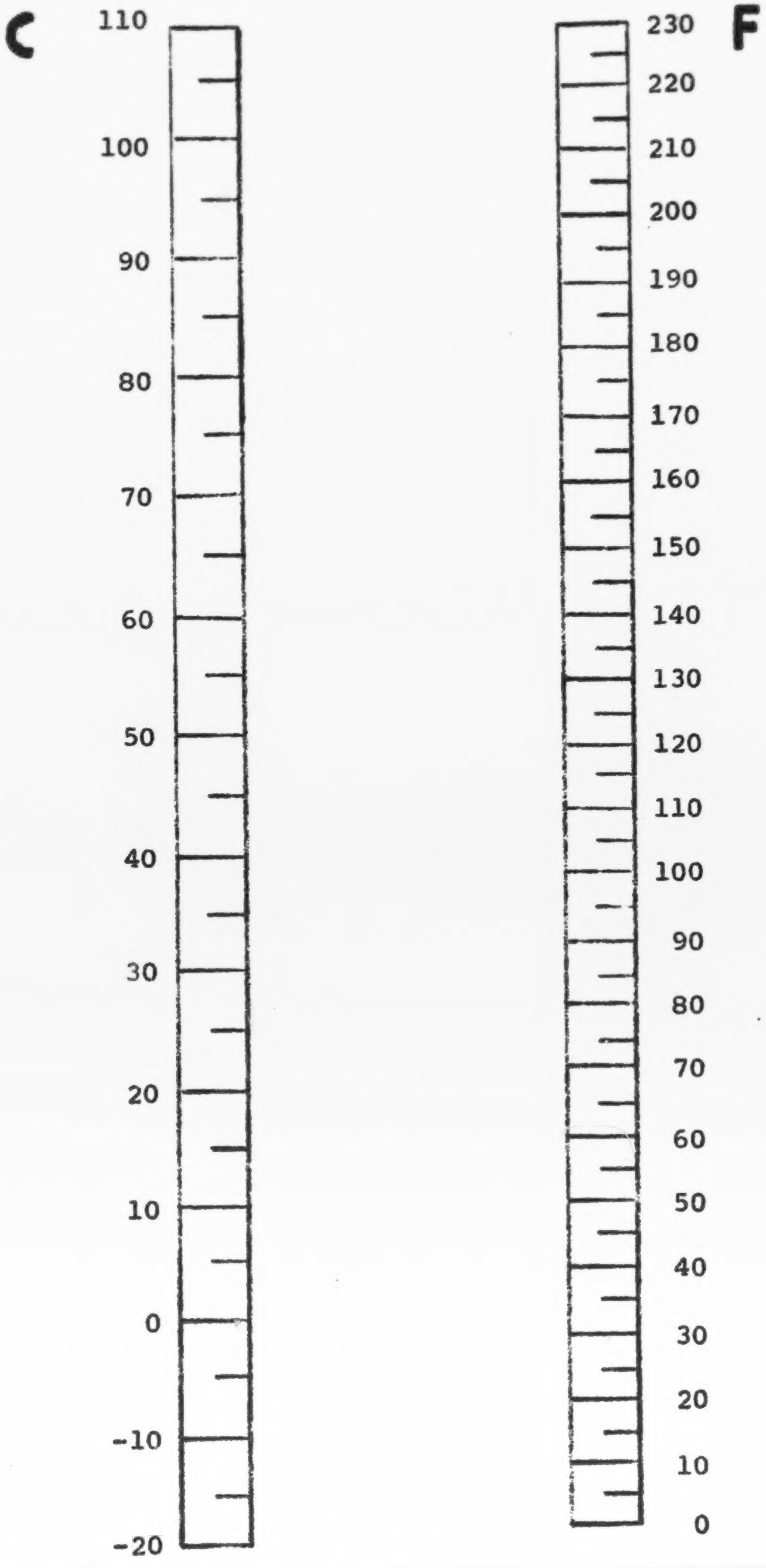
A 24

TIME REVOLUTIONS PER MINUTE	WAIT 3 MINUTES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

A 24


E
PISTON
CYLINDER

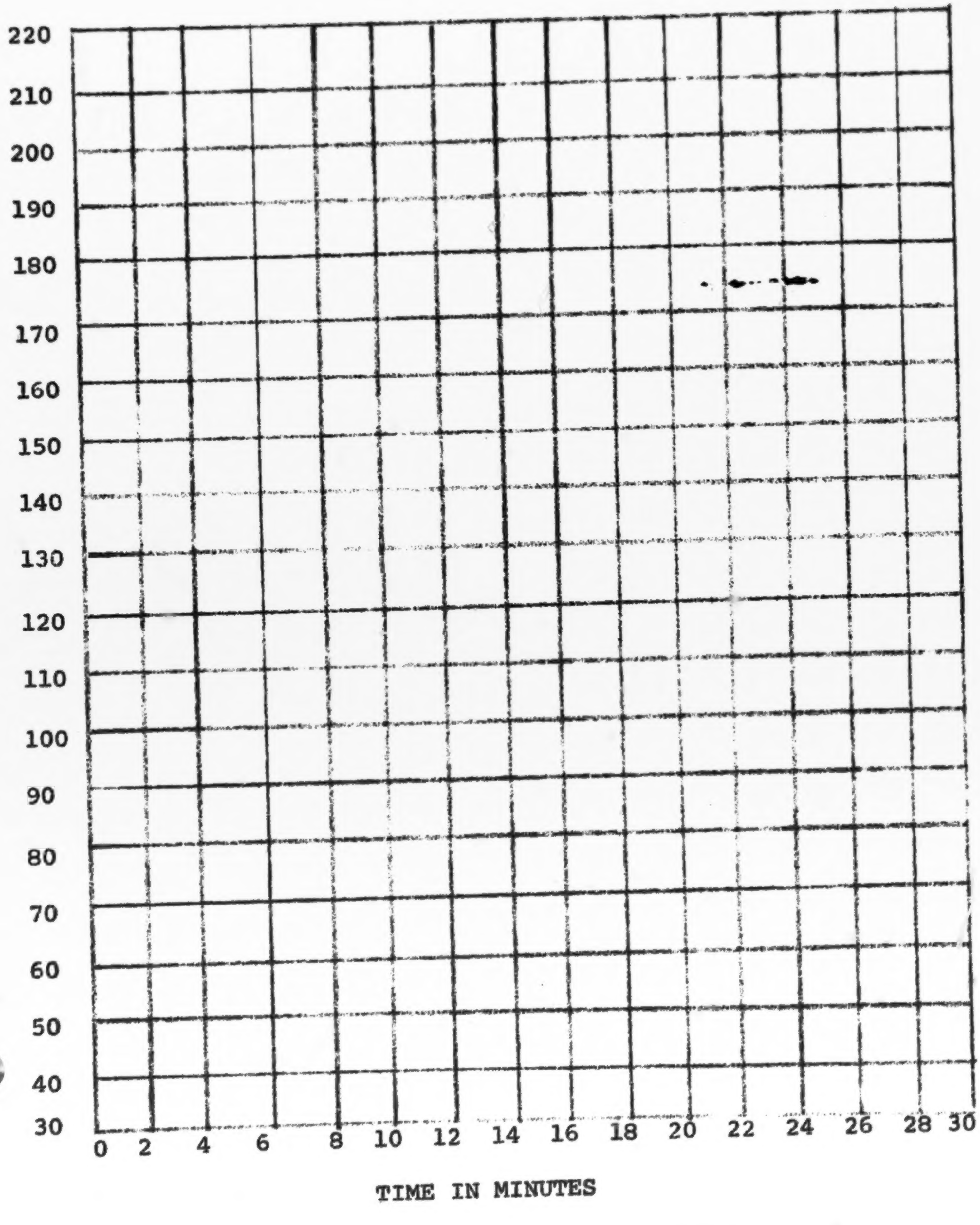
A 25


C
-10
-20
F

A 25

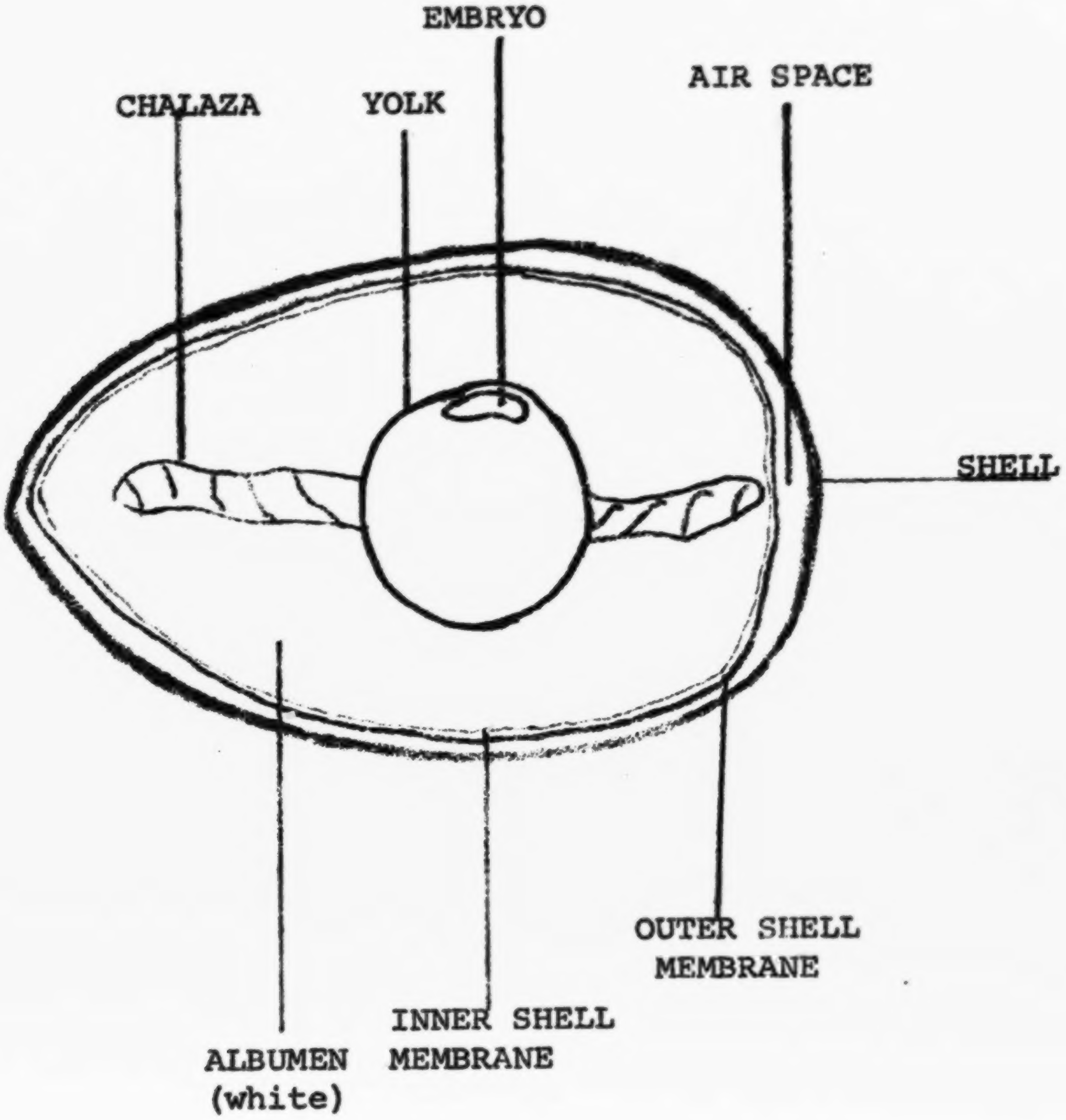
TIME	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
FAHRENHEIT TEMPERATURE																

26


220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
TIME IN MINUTES

A 30

INTERNAL STRUCTURE OF HEN'S EGG


EMBRYO
CHALAZA
YOLK
AIR SPACE
SHELL
OUTER SHELL MEMBRANE
INNER SHELL MEMBRANE
ALBUMEN (white)

A 33

Amount of water										
Temperature change										

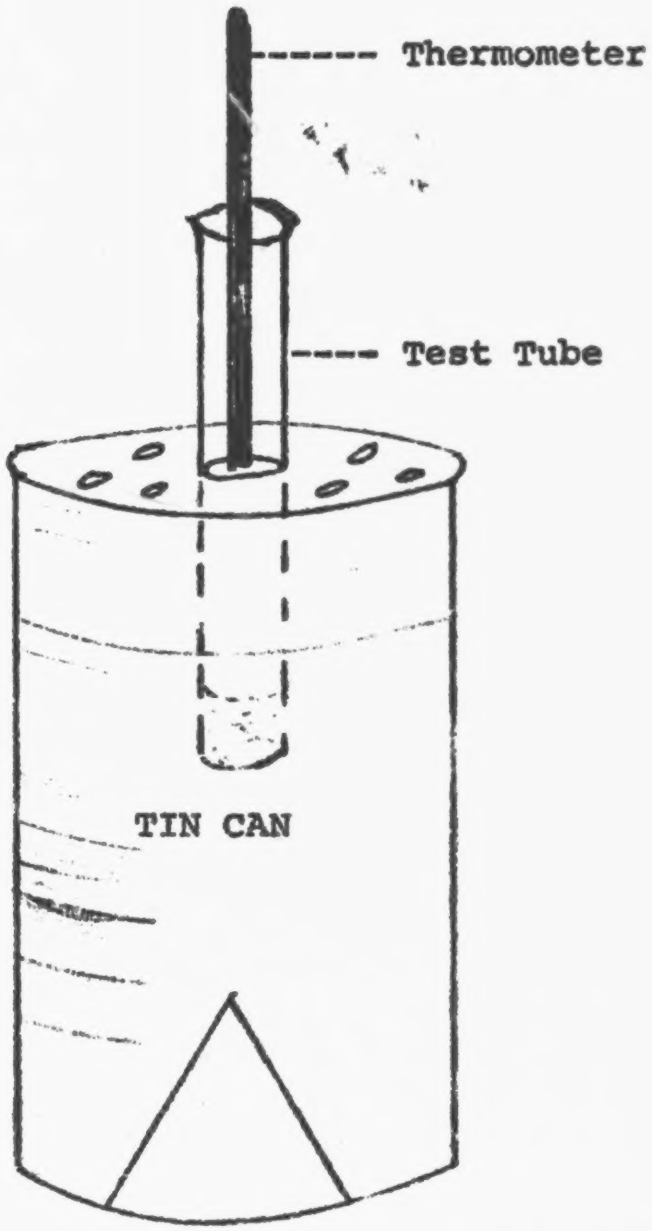
AVERAGE AMOUNT OF WATER ______________

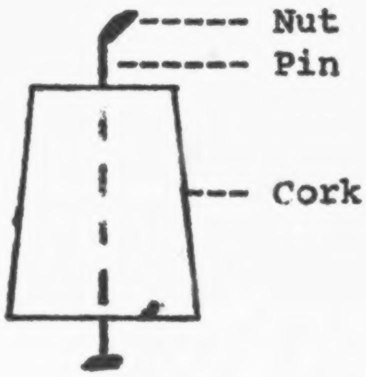
AVERAGE AMOUNT OF TEMPERATURE CHANGE ______________

$$\text{CALORIES} = \frac{\text{temperature change}}{\text{amount of water}}$$

= ____________________ = _________ CALORIES

A 33


Thermometer
Test Tube
TIN CAN


Nut
Pin
Cork

1 Egg White - 16 Calories
1 Egg Yolk - 61 Calories
1 EGG - 77 Calories

1 Cup Peanuts - 840 Calories
1 Cup Pecans - 740 Calories

Peanut Butter Sandwich - 350 Calories

Egg Sandwich - 285 Calories

ICE AND
WATER
32°F

1. Remove Ice
2. Place your hand in the water for 2 minutes

WITHOUT MOVEMENT

Temperature Differences											

AVERAGE _______ °F

WITH MOVEMENT

TEMPERATURE DIFFERENCES											